MUSIC

Buildings
Rooms
Equipment

Music Buildings, Rooms and Equipment

A revision of Music Education Research Council Bulletin No. 17, prepared by the 1952-54 Committee on Music Rooms and Equipment. Published by the Music Educators National Conference, a department of the National Education Association of the United States

MUSIC ROOMS AND EQUIPMENT was the title of Music Education Research Council Bulletin No. 17, adopted by the MENC as an official publication at the biennial convention in Cleveland, Ohio, April 1932. Chairman of the Research Council's subcommittee which prepared the bulletin was Joseph E. Maddy.

A second edition embodying a number of minor revisions (1938) and subsequent reprintings were required by the constant and increasing demand for the bulletin, which was and still is the only publication giving exclusive attention to planning for special construction and equipment needed in the music education program in the schools.

In 1949 a completely revised and much enlarged edition of the Music Rooms and Equipment bulletin was prepared by the late Clarence J. Best in collaboration with William R. Sur (at that time chairman of the Research Council), with assistance from various members of the MENC, and specialists in other fields. The new bulletin extended the success of its predecessor and became one of the most useful and widely called for publications issued by the MENC. It can be said that Bulletin No. 17 has made a definite contribution to the improvement of teaching facilities in the field of music, and has been used to assist in the planning of a great many of the fine music rooms and buildings that are in use today.

Because of the rapid developments which affect building techniques, materials, and equipment, and also because of the expanding needs of the school music program, another complete revision of the bulletin was indicated. The task of preparing such a revision was accepted by the MENC National Committee on Music Rooms and Equipment, and work began at the Philadelphia biennial convention of the MENC in 1952. The completed material was accepted and approved for publication by the Publications Planning Committee acting on behalf of the MENC Editorial Board, Music Education Research Council, and Executive Committee at the time of the biennial convention held in Chicago in 1954.

While certain acknowledgments appear in the text, it is impossible to recognize individually all whose useful suggestions and ideas were helpful in the preparation of the material for these pages. It is sincerely hoped that every person who thus assisted will accept this mention as a very personal "thank you" from the Committee on behalf of all colleagues and friends in the MENC.

In this statement it is proper, however, to give special recognition to certain subchairmen of the Committee and those who assisted them in the various special areas indicated: Frank D. Miller, Illumination, and Carl Allen of the General Electric Company who assisted him; E. Lawrence Barr, Planning the Music Facilities; Allan L. Niemi, Location and Types of Music Rooms; Herbert Shive, Auditoriums; Sheldon Westman, Equipment and Storage Facilities; H. W. Arentsen, Furniture and Risers; Russell Switzer, Floor Plans and Storage Facilities; Paul Stoughton, Audio-Visual Aids, and James Nickerson, a member of the MENC National Committee on Audio-Visual Aids; Wallace Garneau and Leonard V. Meretta, who reviewed and made helpful contributions to Mr. Stoughton's material.

The looseleaf form in which this edition is printed provides for revisions or additions which are anticipated from time to time. These may include complete sections prepared to replace sections which become obsolete, or articles pertinent to a specific area published in the MUSIC EDUCATORS JOURNAL. Also there may be added from other sources material, suggestions or ideas which are important to the planning and maintenance of music facilities.

ELWYN CARTER.

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Introduction

THE INSTRUCTION OF CHILDREN is the primary function of the schools. Although the school plant and equipment usually are classed in a non-instructional and therefore secondary category, it is imperative that the community provide the teacher with the proper physical suroundings and equipment to obtain maximum teaching and learning efficiency. The music activities should be housed in rooms which have been carefully planned for their specialized needs.

It is highly important that school music teachers and administrators be aware of some of the special factors that must be considered in planning the music rooms and facilities for teaching, practice, and performance. A few years ago this was a particularly difficult problem, and was too frequently solved by processes of "trial and error." Guesswork was necessary; the information was not available. We are now beyond the experimental stages and can present sufficient information so that all factors can be studied and each school and community can make the decisions to suit their individual needs. School architects, acoustical experts and others have worked with the school administrators and music teachers in a large number of communities, and outstanding music rooms and music buildings are now available for inspection. Music teachers and school administrators are aware of the specialized needs of the music departments, so that the complex problem is no longer insurmountable.

It is imperative that teachers take an active part in planning the rooms that they use for instructional purposes. Music teachers should have definite ideas as to the specialized needs in their departments. As a rule the departmental needs will be taken care of if the suggestions are submitted early in the pre-planning stages. A careful study must be made of the present and future music offerings in the school and community before the building needs can be determined. Future expansion must be considered.

Multiple Use and Full Utilization

School music rooms are somewhat more expensive to construct than "ordinary" classrooms, and it is important that this fact be faced early in the planning. Before expenditures are made the school administrators and taxpayers want assurance that there is full utilization of space, and that present and future needs are realized. If the school music activities do not make full use of the music rooms during the day, provisions should be made for other music and non-music groups to use the facilities—especially at hours when there would be no interference with the school music program. A large music rehearsal room can be used for audio-visual needs, lectures, declamatory contests, debates, and other group meetings. Small practice rooms can be used for committee meetings, phonograph listening purposes, or as dressing and make-up rooms for the play-production staff—i.e., if located near the auditorium stage. It is also possible that some of the community educational, recreational, civic, social, and service organizations can make use of the music facilities. These are merely ideas to show full utilization of the space, so as to make it possible for the music department to get the specially constructed rooms—until such time that they can justify full use for their own needs.

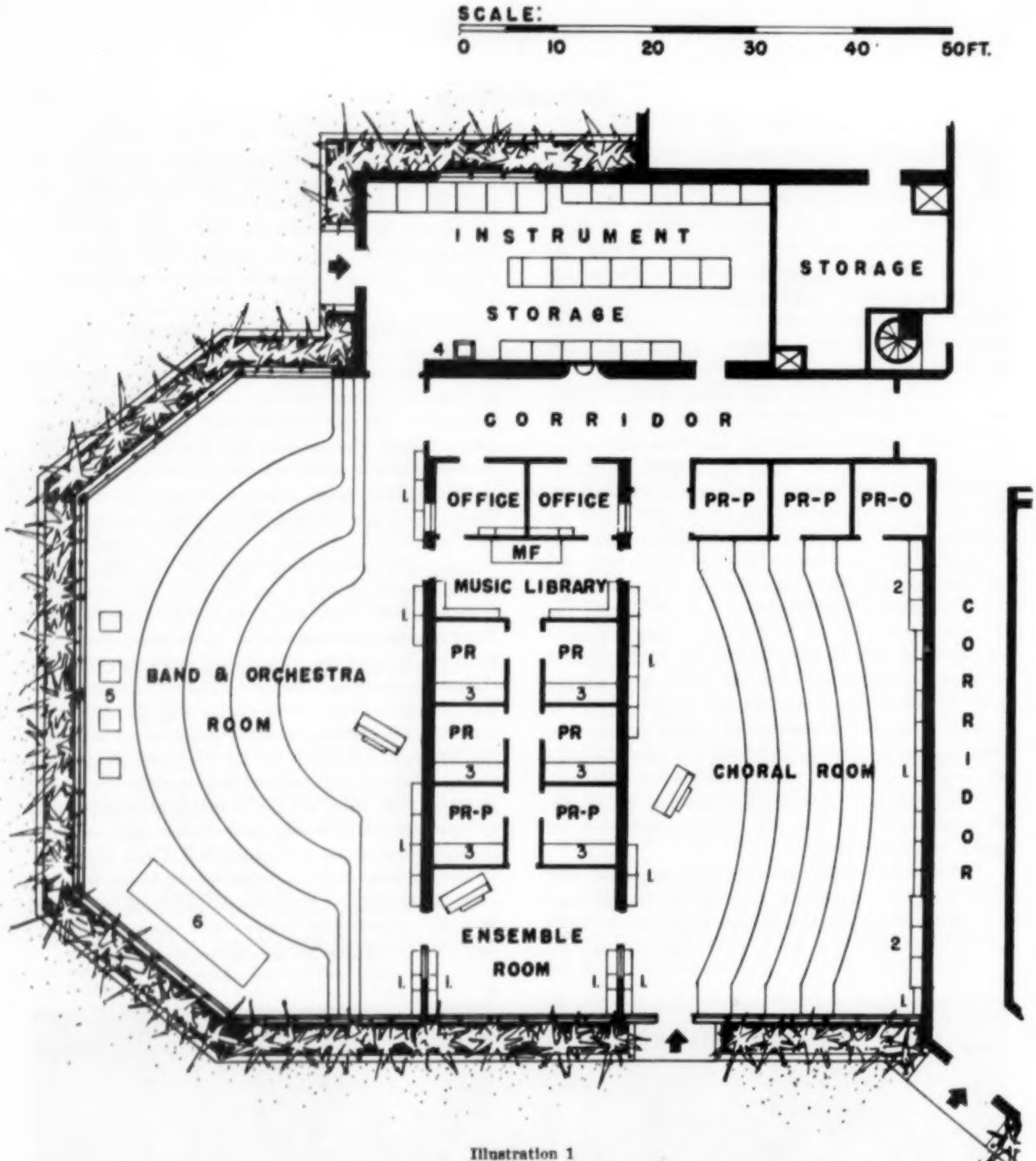


Illustration 1

A PLAN FOR A MUSIC DEPARTMENT WITH TWO OR MORE TEACHERS

South Junior High School, Kalamazoo, Michigan. Lewis G. Kingscott & Associates, Inc., Architects and Engineers

Legend

MF	Music Files
PR	Practice Room
PR-P	Practice Room with Piano
PR-O	Practice Room with Organ
1.	Shelving
2.	Choral Robes, Storage Cabinet
3.	Band Uniforms, Storage Cabinet
4.	Instrument Sink
5.	Sousaphone Chairs
6.	Percussion Section

II

Planning the Music Facilities

PLANNING a school's music facilities calls for cooperation of the entire music department staff with the school administration and the building committee. The following suggestions[1], as will be noted, are based upon such complete internal cooperation and also involve consultancy with experts in the various related areas of planning and construction.

1. Determine and state concretely your basic philosophy of music education.

2. List its implications for:

   Musical activities
   Classroom floor space
   Instrument storage space
   Chalk and tack boards
   Audio-visual materials
   Practice Rooms
   Musical equipment
   Room acoustics
   Soundproofing
   Storage compartments
   Cabinet storage

3. Analyze the new building's potential for present and future needs.

   (a) Maximum enrollment in future years based on survey of population trends. Percentage of student body to be served.

   (b) Total teaching staff needed for your program. Relative economic amount which can and should be devoted to music.

4. Consult the planning of others who are actively engaged in school administration, construction and financing plans.

   (a) Check articles in current periodicals which are especially concerned with education, music education and school administration, as well as architectural construction, equipment, etc. (see Bibliography in this volume).

   (b) Visit other schools.

   (c) Check architects plans on file.

5. Consider accessibility of music area to the remainder of the building, and its possible usefulness for other school and community activities.

6. Make careful preliminary sketches of music unit layout.

7. Make detailed lists of buildings and equipment items:

   (a) Buildings (built in or attached): Chalk

[1] By E. Lawrence Barr, supervisor of music, Kalamazoo, Michigan.

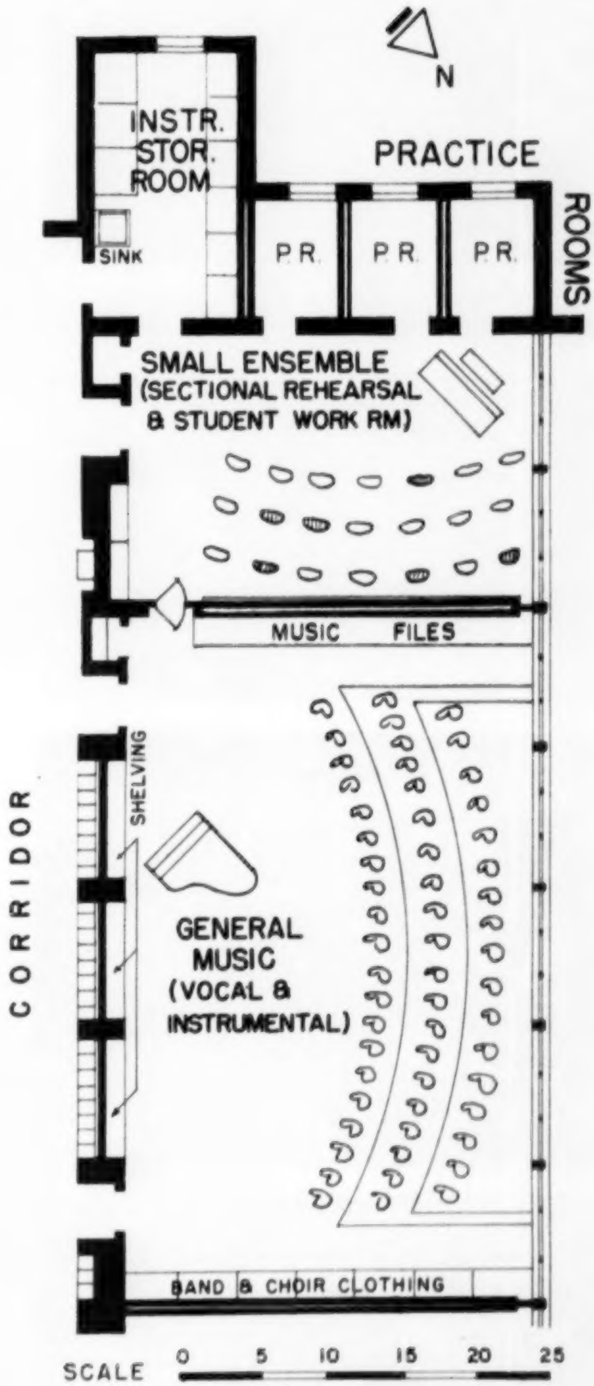


Illustration 2

A ONE-TEACHER MUSIC DEPARTMENT PLAN
Northeast Junior High School, Kalamazoo, Michigan

and tackboards, display rails, map and picture screen installations, bookcases, closets, risers.

(b) Equipment: All movable furniture, instrument storage, cabinets, desks, tables, files, chairs, pianos, instruments, etc.

8. Review each step in terms of philosophy and enrollment.

9. Prepare your materials in writing. Make duplicate copies and secure understanding and approval of all concerned.

10. Keep in touch with your building committee.

11. Meet your architect.

(a) Discuss your materials with him.

(b) Accept his suggestions in terms of total building layout.

(c) Emphasize the problem of room acoustics and soundproofing.

(d) Check frequently with him on preliminary and final drawings. Pay special attention to acoustics and the details of mechanical drawings.

(e) Determine carefully items which will be included in the building contract by checking carefully the architectural plans sent bidders between the time they are completed by the architect and the prices are submitted by the bidder.

12. Watch your building grow.

(a) Make the acquaintance of the construction superintendent.

(b) Follow up on plumbing, wiring, heating, and acoustical treatment work in progress.

(c) Report accidental omissions and other problems to the architect or clerk of the works before it is too late.

(d) Select your building equipment.

Illustrations 3, 4, 5 and 6

From the top down: (3) Ensemble Room, South Junior High School, Kalamazoo, Michigan. Showing a small segment of a general-music chorus rehearsing between the regular chorus and the band. (4) Band and Orchestra Room, South Junior High School, Kalamazoo. (5) General Music Room—Vocal and Instrumental, Northeast Junior High School, Kalamazoo. Students in action as they sing, play ukuleles, and participate in a folk dance during a general music class. (6) Small Ensemble Room, Northeast Junior High School, Kalamazoo. Instrumental students rehearsing in a small classroom situation adjoining practice rooms to which they may be sent as individuals or smaller groups, and still remain under supervision of their teacher.

Illustration 7

BAND AND ORCHESTRA ROOM

The Norman, Oklahoma, High School received first honor award for a school building at the eighty-sixth national convention of the American Institute of Architects in 1954. The band and orchestra room is shown at right. In the background are five practice rooms. Architects: Perkins & Will, Chicago; and Caudill, Rawlett, Scott and Associates, Bryan, Texas.

Illustration 8

MUSIC ROOM

Exterior view and music room of the South Junior High School, Pittsfield, Massachusetts. Architects-Engineers: Perkins & Will, Chicago, Illinois.

III

Location of the Music Rooms

FACTORS TO CONSIDER in planning the location of the music department include a number which have important aspects in relation to the other classrooms in the school. These items include:

(1) *Convenience to the Auditorium Stage and to Other Classrooms.* The large instrumental rehearsal room should be adjacent to and on the same floor level as the auditorium stage. For sound insulation purposes, it is well to provide a corridor or storage space for the music library or instruments between the stage and the music unit.

(2) *Vertical Travel.* Avoid the second- or third-floor location, unless a service elevator is available for transporting the heavy musical instruments and equipment. If there is a choice in the placement of the vocal and instrumental large rehearsal room in a two-story unit, the instrumental groups should have preference for the ground floor location.

(3) *Outside Entrance.* A direct outside entrance is recommended for the music unit, so that the main school building can be locked during the evenings when the music rooms might be in use. This door will facilitate moving the equipment and instruments in and out of the building whenever the music groups perform in other schools and communities for music festivals, athletic games, exchange concerts, etc.

(4) *Convenience to local athletic field.* Important consideration for the marching band activities.

(5) *Music Rooms a Compact Unit.* All music rooms should be close together, so as to form an easily managed unit. This is particularly important in a department employing one music teacher, where the problem of supervising the practice activities is significant. The music library and instrumental storage rooms should be convenient to the rehearsal rooms.

(6) *Sound Insulation to Reduce Disturbances to Other Classes.* The natural isolation of the music unit from the other classrooms is worthy of some consideration, although the outstanding developments in the sound insulation (proofing) and acoustical treatment of the music rooms and the use of mechanical air-conditioning systems has made the problem of physical isolation of the music department less important than it was a few years ago.

Separate Building or Wing of Main Building

Problems of building cost, heating, and maintenance have counteracted the advantages of a separate building. The problem of travel distance to other classes and to the auditorium has made this location less desirable, particularly in areas where the summer and winter inclement weather is a problem. Some schools have constructed a connecting tunnel which leads directly to the main building and to the auditorium.

Location in a wing of the main building can provide natural isolation and also reduce or eliminate the disadvantages and problems mentioned above.

Auditorium Stage

Since the music department would never have exclusive use of the stage, this location presents several disadvantages. Each time the auditorium is used for other purposes, the music instruments, stands, and other equipment would have to be moved to a safe storage area. It is particularly confusing during the weeks that the drama department uses the stage for plays and other productions.

However, there are also several obvious advantages to this location; it is a sound idea to rehearse the music groups in the same physical environment used for the concert performances. This plan eliminates the adjustments to different seating arrangements and acoustical properties. If adequate storage facilities are provided backstage, the chairs, music stands, and other equipment would not have to be carried far. Since music groups rehearse many hours before their performances, most music teachers would rather practice in their own rehearsal rooms (without interruption or scheduling problems) and forego some of the advantages afforded by rehearsing exclusively on the auditorium stage.

Often a school system will plan the auditorium stage at one end or one side of the gymnasium. If the music department is expected to use the auditorium stage in this arrangement, scheduling then is almost impossible. A music rehearsal cannot be conducted during gym classes or basketball practice. Misunderstandings are inevitable between the teachers who use the facilities. Some groups are sure to suffer and a continuous program of study and development is impossible. This plan should be avoided.

Gymnasium

Disadvantages of the auditorium stage are emphasized in this location; there are many natural conflicts in scheduling. The gymnasium would require careful acoustical treatment to remove excess reverberations and to make the room acoustically "bearable" for concentrated effort in rehearsals. This location should be avoided.

Top Floor

Even though some isolation is evident, the difficulty of moving the instruments and equipment (to and from the auditorium, and in and out of the building)

is the main reason for avoiding the top floor. This location offers some natural isolation, but the inconvenience for the rehearsals of the school and community groups, plus the tremendous problem of carrying the musical instruments and equipment makes this situation undesirable—unless an elevator is provided. Moving the instruments and equipment up and down stairs and through corridors exposes them to the greater probability of denting, breaking, and other damage.

Other Locations

Basement: Dampness, poor natural lighting, cost of construction, inconvenience, and other problems have fostered a negative attitude toward a basement location.

Ordinary Classroom: Inadequate size is the common problem found with the ordinary classroom for the music department. Any remodeling program would involve acoustical treatment and careful sound insulation to prevent sound interference between adjacent rooms.

Other Possible Locations: Some schools have utilized some of the space underneath the bleachers in football stadiums, and others have used the space above the school garages. Many places are worthy of consideration, but great care should be exercised in the selection of a site.

IV

Types of Music Rooms

THE SIZE of the school or community is not always a good indication of the possible size of the music department or the size and number of music rooms. Some small communities will employ a large music staff and will offer both an extensive and intensive music program to the school and community. Other schools may employ only one music specialist to do the vocal and instrumental teaching. With this in mind, the music department building needs will be analyzed with the primary determining factor being the number of teachers employed by the schools to take care of their music activities, rather than school enrollment or area population.

Music rooms can be divided into two classifications, depending on their function: those housing the rehearsal and the instructional activities, and those serving in the auxiliary capacity—i.e., storage, workroom, office, and others.

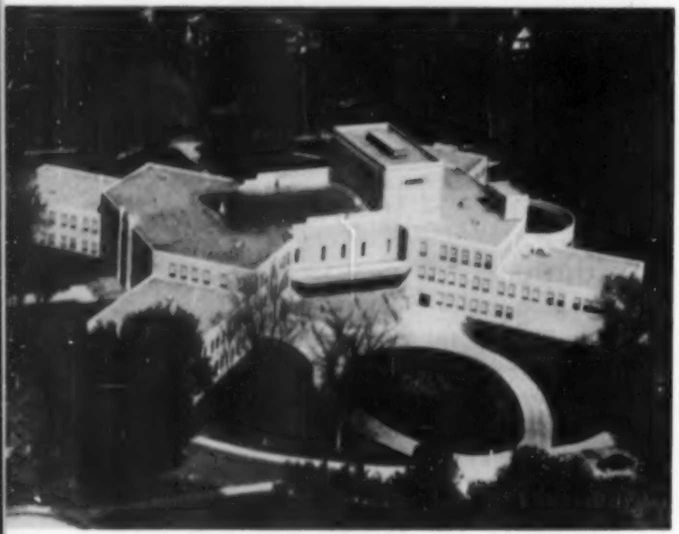
Large Combined Vocal-Instrumental Room

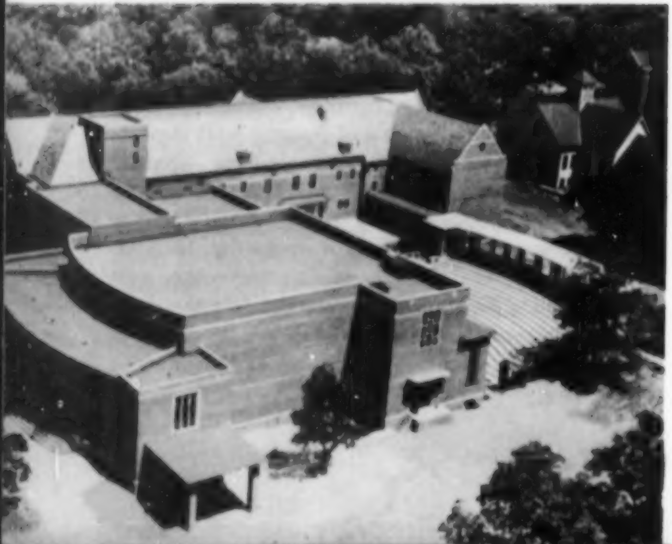
This room is the nucleus of all the music activities. In the smallest music departments a single, all-purpose room can be planned to accommodate the vocal and instrumental group rehearsals, small ensemble and individual practice, library, instrument and equipment storage, instrument repair facilities, office, teaching studio, as well as the classes in music appreciation, theory, etc. Large departments will naturally seek to provide special rooms when possible.

Room Size: In estimating the approximate number of square feet of floor space that should be provided for the band and orchestra members, it is safe to say that one should allow 20 square feet per student (i.e., 1,600 square feet of floor space for an 80-piece band or orchestra). This estimate will provide for the necessary space for aisles, music stands, and other equipment needs. It is easier to make the space-requirement generalization for choral groups, since chair sizes are standardized and standing-room space can be readily estimated—then too, music stands and instrument sizes need not be considered in the space allocation. If the vocal groups are to stand for rehearsals, six square feet per pupil will be adequate. The use of fixed chairs on risers will require more space; at least ten square feet is necessary for each pupil if risers are thirty-inches wide. Extra space should be planned if risers with thirty-six or forty-inch width are preferred.

Room Height: The room height should be at least twelve feet, although heights of fourteen or sixteen feet would be better for the large rehearsal rooms accommodating instrumental groups of sixty or more players. The provisions for natural lighting are improved if the high ceilings are planned, since more window space is available, but then again special consideration will be needed in planning adequate artificial lighting and the necessary acoustical materials. In a school employing one music teacher there is no need for separate vocal and instrumental rehearsal rooms, although it would be well to plan some flexibility for future growth.

The all-purpose rehearsal room should be planned for expansion. In some circumstances a combined rehearsal room will be adequate for a school employing two music teachers, although with a larger staff it becomes necessary to enlarge the office (teaching-studio), storage, and other facilities. Naturally, larger schools with large vocal and instrumental departments will find it advantageous to have separate (specially constructed) rooms for their choir and band-orchestra. Only in very rare situations will it prove necessary to have separate rooms for the band and orchestra. The all-purpose unit for one or two teachers should be planned to accommodate the vocal and instrumental (large group) rehearsals, small ensemble practice, library, instrument and equipment





storage, instrument-repair work bench, office, teaching studios, as well as classes in music history, theory, appreciation, and other areas. Other schools will naturally seek to provide special rooms when possible.

The general floor plan needs not be altered drastically to accommodate the community music activities, except that it would be desirable to construct somewhat larger rehearsal rooms for the combined school and community music groups.

Instrumental (Band and Orchestra) Room

The general specifications suggested for the combined vocal-instrumental room describes the needs for the specialized band and orchestra room quite adequately. The room should be large enough to accommodate the largest orchestra or band expected by the school (90 to 100 members is standard).

Risers or Platforms: Differences of opinion will be found concerning the desirability of providing risers in the instrumental rooms. There is no doubt about the fact that the students sitting in the back of the room and the far sides will have some difficulty in seeing the conductor, unless they are seated on elevated risers. A higher conductor's podium will help solve this difficulty. Some schools have purchased or constructed semi-permanent or portable risers for the band and orchestra. This arrangement makes it possible to move the risers into the auditorium for concert performances, although this is a time-consuming task. Others prefer two sets of risers—one in the rehearsal room and the other in the auditorium. If the rehearsal room is large enough, this issue can be settled by using only a portion of the floor space in the back of the room for the terraces. A "telescopic" principle of construction is also possible—specially constructed risers could be placed on rubber-tired wheels, so that the terraces can be extended or "telescoped" into the back wall. With this arrangement as many steps as are needed can be drawn out. This plan allows the greatest flexibility of use. In order to insure a better blending of instruments, the major symphony orchestras have abandoned the use of risers. Orchestra conductors have discovered that when the brass and percussion sections are elevated in the back of the stage, they often over-balance the strings.

If risers are used a width of sixty inches for most terraces will prove adequate. The top riser should have a width of seventy-two inches, since the back of the room ordinarily accommodates the larger percussion and bass instruments. A sixty-inch step will be

ILLUSTRATIONS 9, 10, 11 AND 12
From the top down: (9) Music Building, Montana State University, Missoula: (10) Frasier Hall, housing the Music, Speech, and Drama Departments, Colorado State College of Education, Greeley: (11) Music Building, West Virginia University, Morgantown; (12) Music Building, Florida State University, Tallahassee.

wide enough for a single row of instrumentalists or two rows of singers. In a combination choral-instrumental rehearsal room it would be well to provide an elevation of approximately eight to ten inches for the permanent riser, so that an intermediate step (thirty inches wide and five inches high) can be used for the back half of the permanent riser. This extra riser can be portable, or it can be constructed as a "drawer" to be pulled out from underneath the sixty-inch step whenever needed.

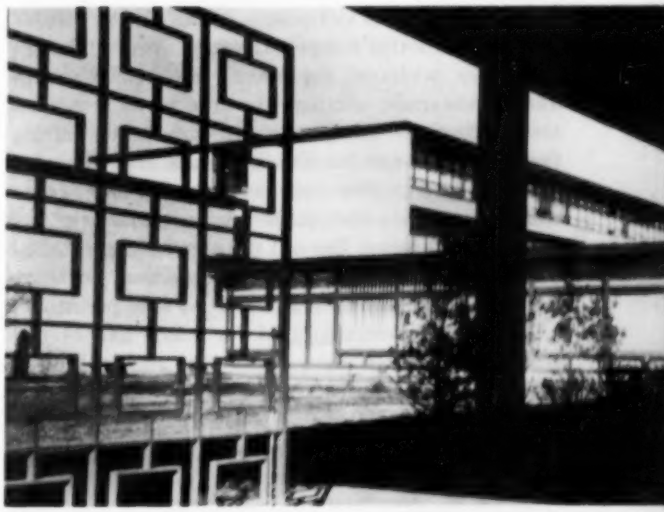
Ordinarily, an elevation of six to eight inches is adequate for the risers. A white strip of paint (1½ inches wide) and/or a rubberized non-skid tread on the edge of all risers provides an element of safety. The number of semicircular terraces will range from one to nine, depending on the size of the room and the needs of the school. General recommendations for the problem of risers in the instrumental music room would be: permanent or semi-permanent risers for a room which must accommodate both vocal and instrumental rehearsals; no risers for the orchestra or band room unless the room is sufficiently large to seat the group on *either* the level floor or on risers, or, if this flexibility is provided, by risers which can be readily folded or "telescoped" into the back wall. Whether or not risers are used, it is a good idea to paint lines on the floor of the rehearsal room to indicate the size of the auditorium stage.

Choral (Chorus and Glee Club) Room

The specialized requirements of choral rehearsal rooms are somewhat different from those room facilities used exclusively for instrumental music groups. Not having to provide floor area for music stands and instruments simplifies the space requirements. Some choir directors prefer that the groups stand for both rehearsals and the performances.

Choral Room Risers: It is an accepted fact that all large choral groups should have risers for their rehearsals and performances. Risers are used so that the tone of the singers in the back will not be obstructed by those standing (or sitting) in front. They are also essential for easy observation of the conductor. An elevation of six to ten inches and a width of thirty inches is adequate for permanent or semi-permanent choral risers.

In order to comply with safety regulations, a center aisle need not be included in a large choral room if the width of the risers and the distance between seat rows is sufficient to allow convenient passage. In such cases the aisle would need to be only on the extreme ends of the row of seats. Safety regulations may differ, but the maximum width of forty inches is



Illustrations 13, 14, 15 and 16

From the top down: (13) School of Music, Arnold Volpe Building, University of Miami, Coral Gables, Florida; (14) High School Community Theater, Berkeley, California; (15) Arts Center, University of Arkansas, Fayetteville; (16) Music Hall, Montana State University, Missoula.

Illustration 17

PRACTICE ROOM—ONE-WAY GLASS PANEL IN THE DOOR

adequate for most choral-room risers in order to insure the proper safety in case of fire or emergency. This fact is mentioned because few choirs desire an aisle in the center of the room.

Supporting posts and pillars should also be avoided in the construction design. The fixed opera (theater) chairs are preferred for seating the choral groups during rehearsals, although the drop tablet armchairs are satisfactory. Some choir directors prefer having their groups stand for the rehearsals as well as for the concerts; in this case the risers should have a width of approximately fifteen inches and a height of eight or ten inches. Several firms make high quality portable choral risers which are excellent for both concerts and rehearsals. Portable or semi-permanent risers are also manufactured for bands and orchestras. Some schools have found that sturdy benches will serve the purpose almost as well as the collapsible risers for the choral concerts.

A portable or permanent stage would be advantageous for the choral room. This can be a valuable room for meetings, recitals, and other programs, since permanent risers and opera (theater) chairs have been recommended. See specifications for room size in the section devoted to a description of the large vocal-instrumental rehearsal room.

Music Practice Rooms

The administrative policies for allowing the students to use the practice rooms before, during and after school hours will help determine the number of practice rooms required. Some authorities recommend that students practice as much as possible in school, so that assistance and supervision are possible. It is particularly important that practice room facilities are provided for those students who play the larger instruments because of the difficulty in carrying the instruments home. These practice rooms should be convenient to the large rehearsal room, so that the moving of the heavy, large instruments is minimized. If a certain amount of floor space is set aside in the building plans for practice rooms, it is better to construct several smaller rooms than a fewer number of larger practice cubicles. It is recommended that the practice rooms vary in size with a minimum floor area of sixty square feet. A room with non-parallel walls (trapezoid shape, with a slant of one foot in fifteen feet) has been found to be superior acoustically, so some schools have made definite provisions for this in the construction plans. Pianos are not absolutely necessary for each practice room, although they are usually in great demand for individual piano practice and for playing the accompaniment for soloists and small vocal and instrumental groups.

Sizes of Practice Rooms: The recommended sizes for practice rooms are:

For band or orchestra instruments, eight feet by ten feet.

For piano, with provision for one other instrument, eight feet by ten feet.

For two pianos, or piano and phonograph (or radio), or for small ensembles such as string quartet, quintet, ten feet by twelve feet.

Illustration 18

SMALL ENSEMBLE PRACTICE ROOM—ONE-WAY GLASS PANEL IN THE DOOR

Location and Other Important Factors: These rooms may and probably should be built in series, along one side of a large music room or along a corridor, with outside windows for ventilation and double glass windows and/or doors facing the music room or corridor, to permit observation without interruption.

Illustration 19

LARGE CHORAL ENSEMBLE REHEARSAL ROOM

Practice rooms should be acoustically treated and insulated against sound transmission to and from other rooms. In this sound treatment, attention should be given to the particular instruments which will be utilizing adjacent practice rooms.

Class Piano Room

Many school systems are now providing class instruction in piano as well as in the band and orchestra instruments. Some schools have constructed specially designed rooms for this type of instruction. These rooms should be as close as possible to the other music rooms in order to realize complete utilization in a coordinated music program. There should be acoustical treatment of the walls and ceilings and insulation against sound transmission to and from other classrooms. There should be given careful consideration to sound conditioning of rooms for class piano if several pianos are used, due to the repercussive action of tone production of several performers. The front wall should be equipped with blackboard (plain and with music staves), bulletin board space, music cabinet, and electrical outlets. Space should be provided for radio, phonograph, and recording machine.[2]

2 For more detailed specifications see Chapter X—Equipment, also Chapter XI—Audio-Visual.

The Director's Office

A music program that functions smoothly should provide a well-located director's office. This is a necessary provision for conferences with members of the community because no other subject makes more frequent and effective community contacts. The size and equipment of such an office depends upon the size of the school. The room need not be especially large but should be quiet and accommodate a desk, two or three chairs, filing cabinets for correspondence, cabinets for miscellaneous storage, and any special equipment such as the Stroboconn, piano, phonograph, radio, recording machine, etc.

General Music Classroom

Regular academic classrooms are used by many schools for classes in music history, appreciation, theory, composition, arranging, and other music education classes. Naturally, special soundproofing and acoustical treatment is necessary. Several pianos for classes in piano and keyboard study can be kept in this room.

Illustration 20

CLASSROOM FOR PIANO CLASS INSTRUCTION
Western Michigan College of Education, Kalamazoo

Music Listening Rooms

Music practice rooms can be used for this purpose, if semi-portable phonograph and radio equipment is available. Other schools may prefer phonograph turntables with earphone attachments. This equipment can be placed in the classroom or study hall without serious interference. Other schools provide comfortable lounging rooms for their music listening activities.

Office (Teaching Studio)

A school employing one or more music teachers should provide teaching and office facilities for *each* full-time music instructor. Great flexibility can be exercised in utilizing this office space; it can be used as a storage room and as a library, or for practice space for the students and the faculty. This room should be larger than the ordinary practice room so as to be satisfactory for class lessons. (See page 62 for equipment.)

Storage Room

The music, uniforms, choir robes, instruments, and other necessary equipment can be placed in specially constructed cabinets and lockers or these materials can be kept in storage rooms. Some schools prefer having several smaller rooms adapted to the more specialized storage needs. The instrument storage facilities should be located to minimize the moving of instruments. The new J. W. Sexton High School in Lansing, Michigan, has made provisions for instrument storage space between the two large rehearsal rooms. This room offers additional soundproofing during the times when there are musical activities in both rooms. Such a room can be used as a workshop for making minor repairs on the instruments. To facilitate distribution, a shelf on the lower half of a Dutch door is recommended for the instrument and uniform storage room.

Instrument Storage Cabinets

Lockers for the instruments should be constructed to promote ready use as well as to protect the instruments. Side hinges are adequate for the compartment doors. In square or rectangular rehearsal rooms, the corner area can be utilized for storage and practice rooms without sacrificing much rehearsal space. Other schools might prefer to construct the deep lockers into the surrounding wall area. The shelves and compartments should be "tailor-made" to suit the instrumental and equipment needs. The back of the room is especially convenient for the storage of the heavier instruments, since that is where they are used during the rehearsals. A maximum depth of four feet and a height of six feet would be adequate for these wall closets. Since most of the smaller musical instruments can be kept in the regular student lockers, it may not be necessary to build specially designed compartments for them. When these smaller instruments are not assigned to the students (i.e., summer vacation period), several instruments can be stored in the larger compartments. Felt or rubberized lining should be placed on the compartments which store the large, uncased brass instruments. To facilitate inspection and provide ventilation, heavy mesh wire windows are recommended for the compartment doors. It is recommended that adequate provision be made so that the compartments can be locked separately.

Instrument Storage Room

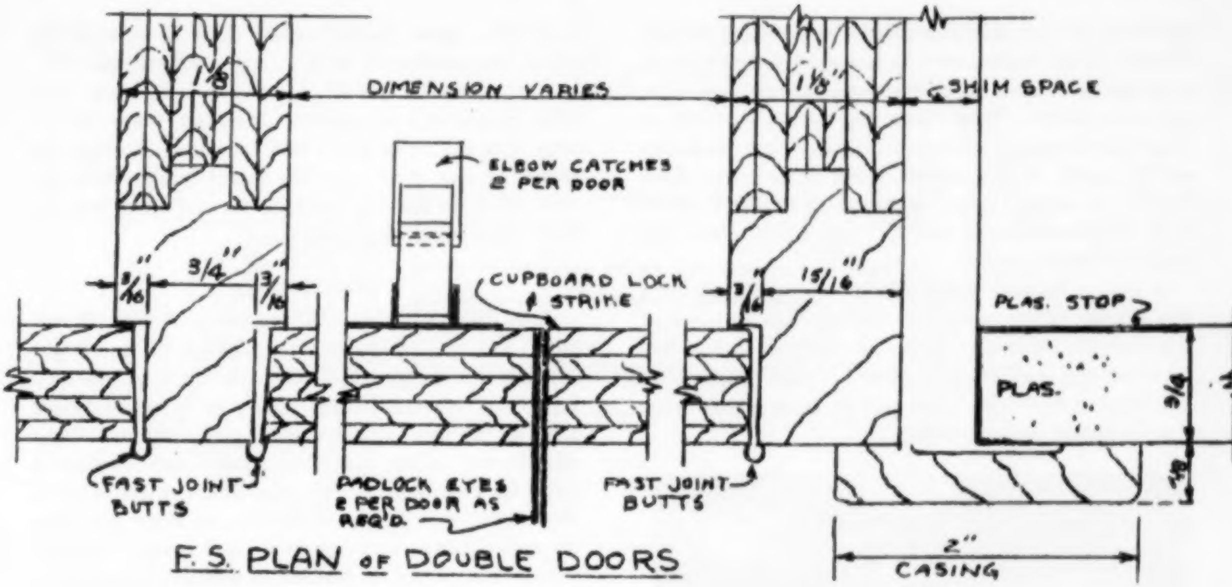
The instrument storage room should be at least twenty feet wide and thirty feet long, with windows placed high along one side, preferably of glass block construction. This type of window placement will permit the use of cabinets below the windows. Along both walls and possibly at one end can be placed closed cabinets of various depths to care for the various musical instruments to be stored. These cabinets should all be the same width and height to make a pleasing appearance in the room. The sizes of cabinets should be no more than a maximum of forty-eight inches in depth, sixty-two inches wide, and eighty-three inches high, including toe space.

In some instances it might be advantageous to extend cabinets to the ceiling or have another set of cabinets built and set upon the lower group for storage of equipment used only once or twice a year. A special stepladder should be kept on hand for reaching this high shelving or locker space.

This room should be well ventilated or protected against excessive moisture or heat or extreme changes in temperature, inasmuch as many musical instruments are made of wood with glued joints. While some schools provide only shelves for storing instruments, this practice is decidedly unsatisfactory since most instruments have removable parts which are easily broken or jarred loose, and they are lost or stolen when instruments are not kept in compartments. The instrument storage room should open off the music room.

Wood instrument lockers built to specifications for musical instrument storage are available from a few leading manufacturers of school storage equipment. Some schools prefer to use metal storage cabinets. Where such is the case, we would recommend affixed felt on the bottom of these cabinets. This cuts down the noise and the possibility of damage to the instruments. Ventilation space should be provided in each door. Care should be taken to make the compartments large enough to avoid hitting the door edges when removing the instruments.

If the instruments are stored in the rehearsal room, additional space for storage must be allowed over and above that required for the rehearsal room. Whether storage is in the rehearsal room or in a separate stor-



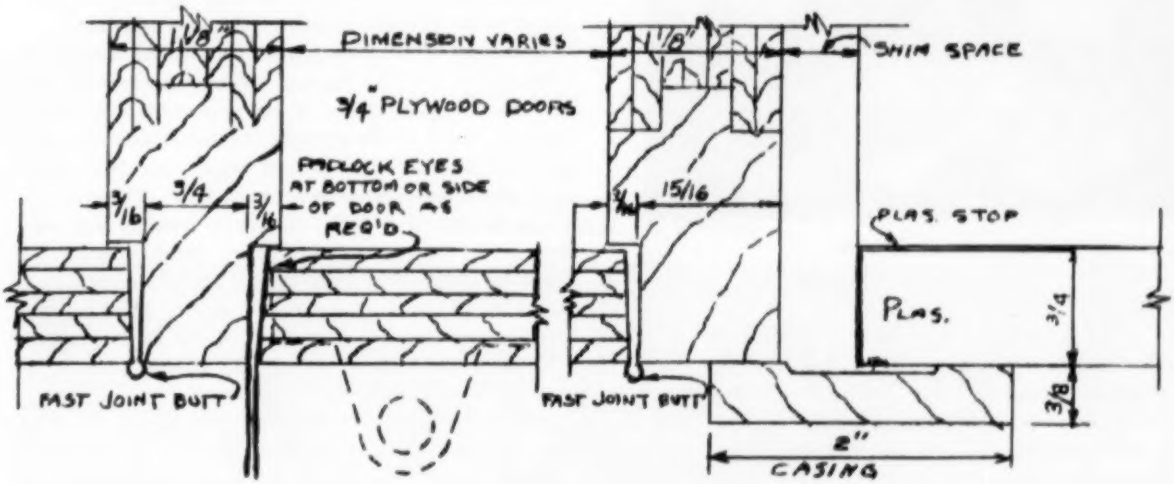


Illustration 21

INSTRUMENT LOCKERS AND DOOR PLANS

Minimum Interior Sizes for Instrument Cabinets

6" x 6" x 36"	Drum Pad, Flute, Piccolo
12" x 6" x 36"	Clarinet, Oboe
12" x 12" x 36"	Bass Clarinet, Bell Front Alto, Cornet, Trumpet
12" x 15" x 36"	Alto Saxophone, Bassoon, Tenor Saxophone, Trombone
12" x 46" x 36"	Baritone Saxophone, Bass Trombone
15" x 8" x 36"	Viola, Violin
15" x 54" x 36"	Cello
22" x 88" x 36"	String Bass
36" x 36" x 36"	Basses (Brass)
18" x 18" x 36"	Alto Clarinet, Baritone, Field Drum, Snare Drum, French Horn

age room, proper facilities should be provided for the storage for *all* equipment. It is a good practice to secure specially built racks for sousaphones, bass viols, and violoncellos. These racks may be made of oak or other hardwood and finished to match the woodwork of the room. Some schools using these racks have lockers or cabinet space arranged so that the entire rack and instruments may be moved into place and thus put under lock.

A new trend now being employed successfully by a few schools is the use of the folding door in place of regular cabinet doors. These are built in such a way as to extend over several cabinet fronts. The use of the folding door also helps greatly in acoustics when door is acoustically insulated.

Illustration 22

ORCHESTRA LIBRARY

Uniform and Choir Robe Storage Room

Storage facilities should be planned for the school-owned band and orchestra uniforms, choir robes, or vestments. This closet space should be cedar lined. A well-constructed, close-fitting door will help protect against moths and dust. The closet space should be high enough so that the uniforms and robes will not touch the floor when hanging on the racks. It is well to notch the pole and label with painted numbers, in order to space the uniforms and robes at equal intervals and to facilitate identification. A separate (pigeonhole) compartment for the caps, belts, and other miscellaneous equipment should also be provided.

Music Instrument Repair Room

Some facilities should be provided for emergency repairs. A special room is recommended although many schools will use a section of the music library room (or director's office) for this purpose. Larger school systems will employ specially trained men to take care of all instrument and equipment repairs. All schools should have a workbench, stool, and a supply of tools for repairs. Cabinet space (with small drawers) should be provided to hold pads, pad cement, springs, cork, and other miscellaneous equipment. If a great deal of repair work is done in the school, the workbench should have a natural gas connection, electrical outlets, wood and steel vises, and other specialized equipment. Running water and a large sink should be fitted into the room. It might be added, though, that often the music teacher will not have the time nor the training for anything but the most urgent emergency repairs.

Music Library

Steel filing cabinets (full suspension, with thumb locks) are frequently used for storing the vocal and instrumental music. The letter-size file is satisfactory for choral music, whereas legal-size is adequate for most of the band and orchestra compositions. Many schools are using specially constructed cardboard boxes for their music. This plan does not use as much floor space and makes it possible to store the same amount of music by using more wall space. This box storage also makes it possible to add new numbers in their proper places without shifting whole file drawers of music to make space for the new purchases.

A sorting rack[3] with five or six slanted shelves is valuable for distributing and arranging music for the individual music folders; it can also serve as a folder cabinet. Many music directors prefer a specially constructed *music folder cabinet* which has individual pigeonhole compartments for each folio. This cabinet keeps the music orderly, facilitates passing and collecting the music, makes a quick check possible on what music has been removed for individual practice, and also provides a convenient way of carrying the music from the rehearsal area to the concert stage. The partitions should have semicircular recesses so that the folders can be easily grasped.

The music library room should be separated from the instrument storage room. However, it is usually desirable and practical to have the two rooms adjoining, both opening off the music room or stage, or both. Space must be provided for work tables, supply cabinets, chairs, and desk. In many smaller schools

[3] Blueprints of Library Sorting Rack, Pigeon-Holed Music Folio Cabinet, and Percussion Cabinet can be ordered from Paul A. Schmitt Music Company, 88 South 10th St., Minneapolis, Minnesota.

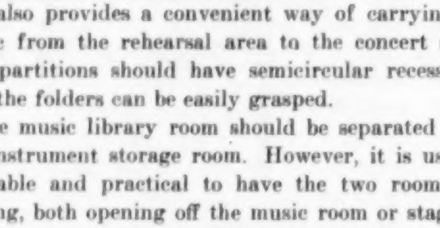


Illustration 23

FLOOR PLANS FOR ONE-TEACHER MUSIC DEPARTMENT

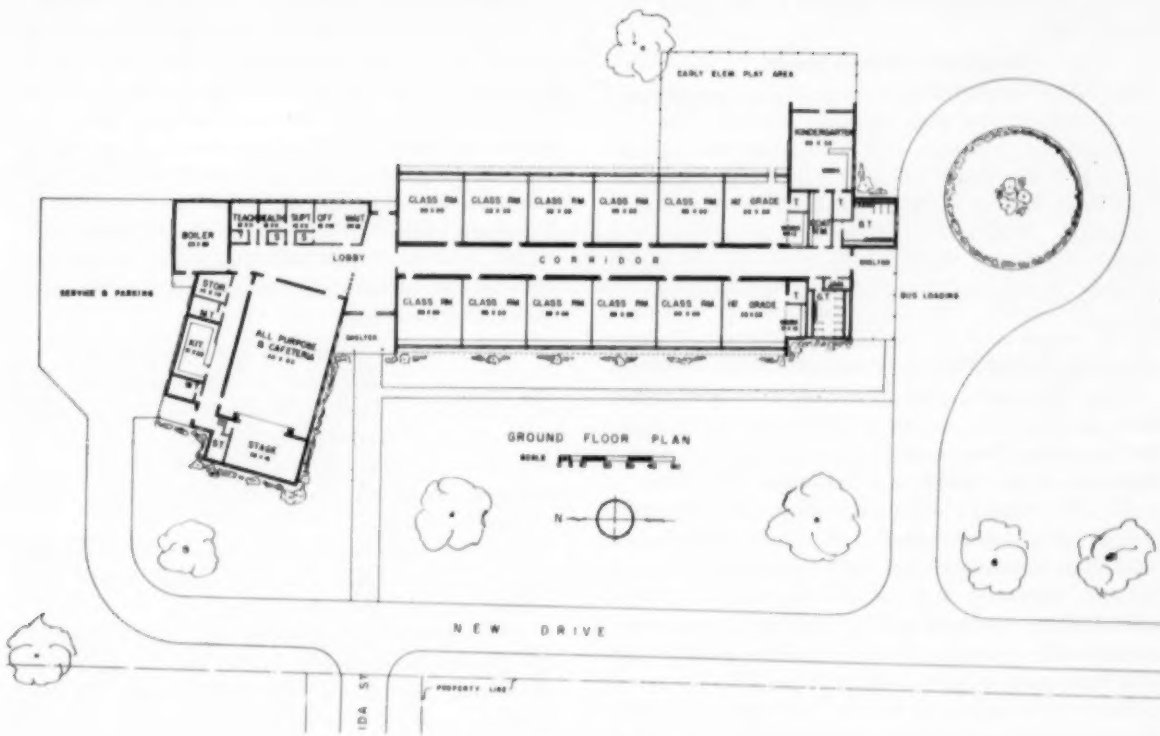


Illustration 24

CAFETORIUM AND SCHOOL FLOOR PLAN
Elementary School, Ida, Michigan

Illustration 25

CAFETORIUM STAGE
Elementary School, Ida, Michigan

the music library equipment is kept in the music director's office.

Broadcast Control Booth

The recent improvements in recording equipment have influenced the work in many schools. The developments in television will also affect the future planning of the school plant. Educational programs of all types will be made available to the school and community. The control booth should be well insulated for sound and should have double glass windows, non-parallel, for viewing the performing groups.

Combined Auditorium, Stage, and Music Room

While this combination is undesirable, it is sometimes necessary for reasons of economy. In the event that the auditorium stage must also serve as a music classroom, the following provisions should be made:

(1) The stage must be large enough to seat comfortably the largest number expected in band, orchestra, or chorus, allowing eighteen to twenty square feet per performer. If the stage is to be used for both vocal and instrumental music, the larger space allotment should be used. Every school has occasional need for a stage large enough to accommodate a large chorus and orchestra or band. This need is usually greater than the need for an orchestra pit. The width of the proscenium in a modern school should not be less than forty-eight feet to accommodate music groups, operetta, and dramatic performances. With a proscenium width of this dimension the proscenium height should be approximately thirty feet.

(2) Convenient and safe storage space must be provided for musical instruments, piano, radio-phonograph, recording machine, music stands, and music library, near or adjacent to the stage. An ideal arrangement would be to have adequate storage space on the stage for this equipment.

(3) If possible, movable risers built in small sections should be provided and convenient storage space provided for them. Some of the commercial types that are built in collapsible sections have proved entirely satisfactory.

(4) All auditoriums should be provided with means for darkening the room for motion-picture use, with electrical outlets conveniently placed for such equipment. Adequate provision should be made on the stage for electrical outlets for those instruments which need electricity for their operation. A film screen and projector should be included in the equipment of every school auditorium. There should also be provision made for an amplification system for music and speech, as well as for important radio programs.

(5) Lighting should be provided for the back of the stage, since the members of musical organizations must face the audience while reading music and watching the director.

Combined Gym, Auditorium Stage, Music Room

This plan has been used in some parts of the country and has proved unsatisfactory. Not only has the progress of the music groups, athletic teams, and auditorium sessions been deterred, but also much friction and misunderstanding have developed among the teachers assigned to use these facilities. This plan should be used *only as a last resort*, and many of the provisions listed for both the combined gymnasium-music room and combined auditorium stage-music room should be carefully incorporated in the plans for such construction.

Combined Gymnasium and Music Room

While this combination is also undesirable, even more undesirable than the combined auditorium stage-music room, it is sometimes necessary for reasons of economy. The following provisions should be made in the event the gymnasium is required to serve also as a music classroom:

(1) The walls and ceilings must be acoustically treated and the room insulated against sound transmission to and from other classrooms.

(2) Safe and convenient storage must be provided for musical instruments, music stands, chairs, and risers, near or adjacent to the gymnasium. The music library should be located in an adjoining room. A small-size piano should be provided *for use of music classes only*, with provision for safe storage in an adjacent room, as should be a phonograph, radio, and recording machine. In case there is no available room nearby for this storage, special covers or boxes equipped with locks should be provided for this valuable equipment. Provision should be made for film screen, blackboard and bulletin board space, dark blinds for windows, and electrical outlets for radio, phonograph, recording machine, movie projector, and electrically operated musical instruments.

Cafetoriums

The cafetorium is one of the more recent innovations to conserve space. While this may be advisable from the point of view of economy, there are few activities that have the same requirements. A music room, a cafeteria, and a theater cannot successfully occupy the same floor space.

Educational opportunities must be offered in such a manner as to give the student the best learning situation. He must achieve the most for his efforts and learn to do his tasks in the best possible manner. Makeshift, make-do, unfortunate substitutions, and wrong tools are a poor approach toward the attainment of the ideals of the American education.

Washroom and Toilet Facilities

The washroom and toilet facilities should be conveniently located to the music department. If the remainder of the school building is locked during the evenings, these facilities should be planned within the music unit.

V

The School Auditorium

There are many school facilities in the planning and construction stage at the present time. It is frightening to consider the amount of money that could be wasted upon improperly designed facilities in those buildings, upon facilities that are not suited for their particular situation, or upon facilities designed to suit specific situations that are not applicable in their particular communities. Many of these designs are based on experience derived entirely from the use of the previous building or quarters. This approach in the planning of the school auditorium is, of course, completely wrong.

One must first decide the purpose for which the plant or building will be used and then determine the qualifications for these different types of activity. An auditorium should be designed so that the activities can be maintained and operated with a maximum of efficiency, and so that they will produce the desired results with a minimum amount of time and labor consumed in the preparation of the event. This area is being designed for an educational purpose. The faults of previous quarters and of other situations should be taken into consideration but these should not be allowed to be the guiding design factor. They may not apply to the new plan.

The school administrator or teacher is not a trained engineer. Neither is the architect a trained school administrator or teacher. People trained in educational fields should be cognizant of the requirements for their particular educational program. The architect is responsible for the design of the facilities required to meet educational needs. The school auditorium involves many different fields both from the educational standpoint and from the construction standpoint. All parties involved, therefore, should be consulted and, if necessary, an investment should be made to acquire the services of the proper engineers. The music teacher should present his situation to the lighting engineer, the acoustical engineer, the ventilating engineer, and the other allied trades. These engineers should then, in terms of this information, present their special design requirements to the architect. The architect in turn must incorporate in plans and specifications those features required for the various specialized purposes.

It is not enough merely to incorporate these various designs on the drafting board, but it should be the responsibility of the school teacher and the school administrator to see that the various engineers follow up their proposals, and that the suggestions are satisfactorily incorporated in the design of the auditorium. The job should be watched to see that the proposals are carried out, and to make sure that the contractor incorporates these special features and requirements in the actual construction. The wise school administrator will consult the music department, both instrumental and vocal, as to its stage construction requirements. He will consult the dramatic department and all other departments of his school and community that will use the proposed auditorium.

Many school boards and school men make extensive tours, viewing other school plants. These tours are extremely valuable and educational, and from them the school men should glean many new and startling innovations. To use the phrase often used in various industrial suggestion systems—"there is always a better way." Is this better way the best way for your particular situation? A school must not be handicapped with an inadequate, improperly planned auditorium. Maybe it would not be practical and economically possible to have all the items desired, but they can be incorporated in the plan so that if the opportunity presents itself these items may be added without undue structural changes.

The information supplied here applies to many specific situations, but does not represent an effort to set forth hard and fast rules. Since educational situations vary in accordance with the community and the students attending and using the educational facilities involved, the material presented covers a wide range of needs and conditions.

Illustration 26

TYPICAL SCHOOL AUDITORIUM
Berkley High School, California

Proscenium

The stage is considered first because it is the part of the auditorium most frequently abused by the designers.

The proscenium arch* size is dependent upon several factors—the size of the auditorium, the playing area of the stage, the height of the stage loft or grid, the size of the community using the auditorium, and the logical seating capacity of the auditorium. Most of these will be discussed in more detail later. For general purposes the proscenium arch should not exceed 65 or 70 feet in width, and the height of the auditorium should be in practical or artistic proportions to the width. This height is an important factor that will determine the location of the grid. The grid also will be the subject of a separate discussion. All these items are interrelated, and the architect must consider all of them as they relate to each other.

The playing size of the stage will be determined by the sizes of the musical organizations, and the stage requirements of musical or dramatic productions, or of other activities proposed for this stage. Clarence J. Best recommended in his survey that an orchestra player be alloted 18 square feet of floor space for himself, his instrument, and his music stand. This is a generally accepted figure. For practical purposes the requirements for band are about the same. A 100-piece orchestra would require about 1,800 square feet of floor space, or an area about 50 feet wide and 36 feet deep. The stage will have to be proportionately larger if the instructor is planning to rehearse and use combined choral and orchestra concerts. As an educator the instructor must determine such conditions as these.

The off-stage area is often overlooked, yet it is a very important functional part of the stage. In presenting concerts, operettas, plays, etc., some area off stage is necessary to handle personnel, scenery, and equipment. These areas are often too small. The left off-stage area should be approximately one-half the size of the stage plus ten per cent, and the off-stage right area should be the same size plus sufficient space for pin rail, switch board, and similar permanent features. A large proscenium opening can always be made smaller through the use of curtains, flats, teasers, etc. If the major architectural construction is too small, increasing the size of the proscenium is very difficult.

* The curtain and its framework.

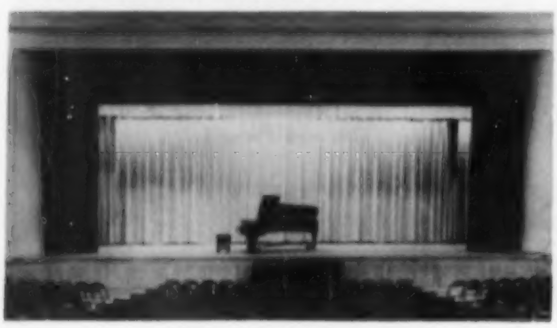


Illustration 27

PROSCENIUM, VIEWED FROM AUDITORIUM
West Virginia University, Morgantown

A good proportion to follow in determining the depth of the stage is that the depth should be 75 per cent of the width of the proscenium arch, and this depth area should continue on both sides of the stage. To use simple figures, if the proscenium arch is 48 feet, the depth of the stage should be 36 feet. The off-stage area to the right would be 24 feet wide plus ten per cent and 36 feet deep plus that area necessary for permanent equipment, such as pin rail and switch board. The area off-stage left would be 36 feet deep and 24 feet wide plus ten per cent. This off-stage area could handle stage wagons that would cover the entire playing stage. It would be of sufficient size to store a number of stage sets for musical and dramatic performances.

The off-stage areas should be readily accessible to dressing room space for band, orchestra, and dramatic or musical show casts. There should be adequate space close to the stage to take care of lighting machines, lighting cables, repair and supply parts, and storage for curtains and other stage equipment. In all educational situations it is practical to have the rehearsal rooms for chorus, orchestra, and band in close proximity to the stage in order to facilitate the preparation for rehearsals, concerts, and recitals.

The instrumental storage rooms, library rooms, scenic shops (including painting racks), and construction areas should be close enough so that properties can be shifted onto the stage with a minimum of effort and damage.

Apron

Extending in front of the stage should be the stage apron. This apron should be at least six feet wide so that pianos and other equipment may be used in front of the main curtain. This apron may extend out over the orchestra pit. The front of this stage or apron should be finished with a hard oak or maple flooring, and that part in back of the proscenium should have close-grained pine in order that the floor will not splinter and yet will be soft enough to take stage screws. The oak or maple floor should be finished with a high gloss but not waxed, and the pine floor should be finished with many coats of oil and the oil allowed to penetrate the wood thoroughly so that it will be fairly seasoned. On both sides of the stage leading from the auditorium to the stage apron there should be appropriate steps. These steps should be wide enough that personnel may carry musical instruments and other small properties to and from the stage auditorium to the stage, or so that at different times the students may approach the stage at least two abreast.

Grid

One of the paramount faults committed in designing school auditoriums is the fact that the grid over the stage is not high enough for the scenery to be pulled out of sight. The grid should be at least the height of the proscenium arch times two plus a minimum of four feet. Then there should be from four to seven feet above the grid to the top of the building structure, where the people who find it necessary to work on the grid, changing pulleys etc., will have sufficient room. This will make it feasible to hang scenery and pull it out of sight in changing sets. Often there is no space overhead and scenery must be pulled into the wings of the stage. Here again there is not enough space to stack this scenery off stage. Thus the only solution is to make the stage smaller, and of course there is a limit to these make-do methods. The only thing that can be done is to mask out with drapes or flats, reducing the proscenium arch so that the stage is much narrower. Then the stage crews will have to work behind the drapes as a backstage area.

One not too familiar with stage operations or requirements often finds the grid an ideal place to run ventilating pipes, conduits, steam lines, water pipes, etc. Just because this large grid area presents a wide open space, it is a tempting area for various trades; however, this area must be kept entirely free for the necessary stage equipment. Nothing is more distressing than to have guide ropes fouled among ventilating ducts, or to have steam pipes leak in the center of a stage set during a performance or concert.

Battens

A proper stage will have a number of battens suspended from the grid. These battens are long pieces of pipe extending the full width of the stage and continuing backstage so the curtains and legs may be hung backstage in order to mask off this area from the audience view. Battens are part of the permanent fixtures of a stage. The common way to counter-balance the battens is through installation of a pin rail. The standard counter-balancing equipment as supplied by the major manufacturers of stage equipment is usually satisfactory. Makeshift installations supplied by various scenic construction companies should be avoided. Battens should be placed six inches apart. There are never enough pipe battens to take care of the stage curtains, drapes, etc. All the lights, border lights, teasers, a border in front of each strip light, three or four legs on each side, the front curtain, oleo curtain, back drops, and sky drops are all standard pieces of equipment that are hung from battens. Then by the time a light batten or light bridge is added at the fore part of the stage and sufficient battens are provided for changes of scenery, it is not at all unusual to use a minimum of 25 or 30 battens.

Cyclorama and Shell

Most stages are equipped with a cyclorama and a set of cyclorama lights, but this cyclorama should not be confused as a substitute for stage shells. A cyclorama is usually a continuous curtain starting close to the proscenium arch on one side of the stage. It extends to the rear of the stage, across the back of the stage, and comes back front, ending close to the other side of the proscenium arch.

Every stage must be equipped with an adequate shell. For lectures, concerts, and recitals on a theater stage, the purpose of a shell is to project the sound into the auditorium. This shell should not attempt to use border lights for lighting, but the lights should be installed in each section of the ceiling and in such a manner that the stage will be flooded with about 60 or 70 footcandles of light.

The lights should be arranged so that the back row of music stands in a band or orchestra as well as the front row will have sufficient light, and so that the lights will not throw a glare into the audience. The shell should be made the full width of the proscenium and should be made of standard flats of canvas, or lightweight, hard-surfaced construction board, and the usual one- by three-inch white pine boards. These standard flats are supported with the usual stage braces and rope devices. The ceiling will hang from the battens so that the size of the shell can be varied by adding or subtracting flats and adding or subtracting ceiling sections. Often a shell is too dead. It may be livened up by several coats of high gloss enamel.

It is well to remember to use the best grade of white pine for making all scenery. This is a good safety precaution and good economy because this good grade of material may be salvaged and re-used several times in making some of the scenery, whereas the cheaper grades will splinter and break and many times cannot be salvaged.

Stage Ventilation

Backstage ventilation is a serious problem that is often overlooked. In hot weather stages become unbearably hot, especially when a number of high wattage lamps are used. Slow moving, belt-driven exhaust fans are suggested because they create the least amount of noise. This hot air should be exhausted from the upper part of the stage fly or grid. All the air must be moved that can be moved without causing the curtains to sway. Some stages use forced air for heat; again, care should be taken to keep this air from being driven against the stage curtains or scenery. Since the supply and exhaust of air must be directed away from the scenery, it is better to use some other means of heating.

The amount of air supplied backstage should not cause the front curtain to billow. There must be a balance of the air between the stage supply and the

auditorium supply, and between the stage exhaust and the auditorium exhaust. Drafts in an auditorium or on a stage or in an orchestra pit are serious. They can affect stage scenery; they can affect the pitch of instruments performing on the stage or in the pit; they can cause untold discomfort to the audience. The major problem in ventilating an auditorium is to move sufficient air and yet not create drafts or disturbing noise.

Doors

All doors entering on a stage must be of sufficient height and width to provide ready access to the stage. This is especially true of the scenery doors. The scenery doors must be high enough to permit handling of tall flats, and wide enough to accommodate wide stage wagons, large instruments, and permit (if necessary) entrance of motor vehicles. The door for scenery should be at least eight feet wide and fourteen feet tall, and all other doors leading to and from the stage should be unusually wide double doors.

Safety

There are many safety items to be considered on a stage. There must be adequate safety lights; that is, there must be lights that make the entire stage visible for night watchmen and others using this area after hours. The proper counter weights for handling pipe battens, drop scenery, etc., must be installed. Any one of the recognized scenic producers can give advice concerning this. Many states require a fire wall between the stage and the auditorium. The switchboard should be properly grounded; all light battens should be properly grounded so that in case the lights do short out the operators will not be seriously injured. Stage properties can be handled safely only when there is adequate and proper stage equipment.

Every auditorium should be equipped with some form of telephone—sound powered phones are satisfactory in most instances. They should be located at the backstage switchboard, projection room, orchestra pit, front of the auditorium, manager's office, and ticket window, thereby making all stations in complete accord with the different phases of the operation of the auditorium. If they are not required for daily use, they could be kept at the central office; then, when needed, they could be plugged in to the jacks provided at the aforementioned locations.

Lights

The stage switchboard should take care of an adequate number of floor pockets in three or four locations on both the right and left sides of the stage. Also, across the back of the stage there should be at least three or four wall pockets, or floor pockets. Each one of these pockets should be capable of handling three to six 3,000 watt circuits. Again, the quantity of these will be determined by the size of the stage area. *There can never be too many outlets.* It is better to have more adequate outlets than to chance overloading a few. A number of overhead outlets in the way of portable or flexible drop cords, perhaps three or four on each side, are also valuable. Each one of these drop cords should be capable of handling six to eight circuits. Needless to say, all of these arrangements should meet all underwriters requirements. The installation should also be checked with the National Electric Code.

A light bridge or light batten, with sufficient circuits so that it could be filled to its capacity with flood lights, spotlights, ellipsoidal lights, kleiglights, etc., should be located close to the front of the stage on a movable batten and close to the proscenium arch It is also well to hang a long strip of asbestos curtain about three feet wide in back of these light machines, so that they cannot burn the curtains or create other possible fire hazards. This asbestos strip is recommended even though all curtains are supposedly fireproof. The number of circuits on the light batten or light bridge will be determined by the length of the batten. The lights should be close enough together so that they can be focused with a minimum of waste space between each light. All in all, a stage with a 45-foot proscenium and a 30-foot depth should be equipped with a minimum of 75 or 80 light machines.

Some of the technical organizations that provide consulting services should be consulted concerning the kind of light machines to be selected. The stage should be equipped with additional lighting that can be used for rehearsals and put on separate switches. This will save the delicate switchboard equipment from damage through improper use. Furthermore, the technical set-up for dramatic performances, musical shows, concerts, recitals, and other public performances will not have to be disturbed for ordinary classes using the stage for preliminary rehearsals, etc. This additional lighting will soon pay for itself when considering the amount saved in repairs on delicate equipment.

The switchboard should have sufficient circuits so that the lamps can be used wherever needed, and it should have individual and various dimmer combinations. Again, this will depend on the size of the stage. All stages should be equipped with sufficient border lights and footlights usually provided in four colors. Three or four border strips of these lights across the full length of the stage are normally adequate.

Risers

Portable risers should be provided for every stage. These risers should be adjustable to suit choral groups, orchestra, or band. Choral risers should be designed for either standing or seated choruses. The orchestra risers should allow extra space for the percussion, cellos, and bass viols. The same is true with

band risers. These risers should be a part of the regular equipment of the stage. Dramatic productions need additional risers, which should conform with the above in size combinations.

Orchestra Pits

Most school auditoriums need an adequate orchestra pit. The pit should be in direct proportion to the size of the stage and the size of the auditorium and, above all, should be sufficient to house the potential orchestra of the school; that is, the potential school orchestra that would be required for adequate performances of a musical play, operetta, or opera. A stage with a 45-foot proscenium should have an orchestra pit of sufficient size to seat a 60-piece orchestra comfortably, allowing 18 to 20 square feet per player. Likewise, a stage with a 60-foot proscenium should have a pit large enough to accommodate a 100-piece orchestra. With a larger or smaller stage, the pit should be in direct proportion.

Playing an instrument in an orchestra pit sounds different to the performer from his playing on a stage or in a recital hall. In order to give satisfactory performances to the audience, the characteristics of the pit are bound to be different from those of the rehearsal room or stage. The orchestra pit should be treated so that the orchestra tone is subdued but not distorted, and it should be treated acoustically to prevent distortion and echoes. Singers must be heard over a full orchestra. In dampening the orchestra tone sufficient resonance must be maintained to keep a balance of tone and the proper quality of tone.

It is recommended that the type of acoustical block having holes or slots be placed along the entire width of the orchestra pit walls—front, side, and back. The ceiling of the apron over the orchestra pit should not be treated. The floor should be of hardwood or concrete. If concrete is used, peg boards will have to be provided for cello players and bass players. This hard, solid floor will give enough bounce or resonance to keep the tone from being subdued out of proportion as a result of the acoustical treatment. Sometimes directors find that it is necessary to leave part of the acoustical block off the walls next to the string section. In that event all the strings should be placed on one side of the pit, about half of the pit wall on the audience side would be left untreated, so that there is a hard surface to reflect the string tone to offset a heavy brass section. This block should be painted a flat black, with the exception of that portion immediately back of the director, which should be an area about four feet wide and painted white. The director will then stand out both to the players on the stage and to the orchestra players. The black flat paint is recommended in order to eliminate the unnecessary glare and reflection of orchestra lights, because the light from the orchestra pit often interferes with the stage effects. The floor should be painted a flat black color the same as the walls in order to reduce light reflection.

The pit should be deep enough for the orchestra to be completely out of sight of the audience. The director's podium should be high enough for him to be able to see the back area of the stage, yet remain in easy view of the full orchestra.

The railing around the entire orchestra must be high enough to hide the orchestra and yet low enough not to interfere with the sight lines of the audience. The head and shoulders of the director may be visible over this orchestra pit railing, although it is preferable that the director be hidden from the view of the audience in order that there will be no distraction of any kind while the director is giving cues to the various members of the orchestra, cast, and performers.

Hydraulic Pit

A movable pit floor, usually known as a hydraulic pit, is highly desirable. The hydraulic pit floor should come up to stage level and then be lowered to the floor below. In this event the access will be a simple matter through double doors, and the problem of determining adequate pit levels for performance is immediately solved. The hydraulic pit floor will act as a good sound reflector when not being used as an orchestra pit. At that time the pit will probably be located slightly below the stage level.

The orchestra pit, whether hydraulic or stationary should be connected with an inner communicating system with stations backstage and to the front of the house with appropriate signal lights and/or signal buzzers.

Orchestra pit stands are stands that are definitely designed for an orchestra pit. They prevent light from spilling over and are large enough to hold the special and unusual sizes of manuscript. Each orchestra pit stand will have one or more built-in lights whose rays will strike the paper at a low angle, so that there will be a minimum of light. Light that spills off the stand is apt to interfere with various stage effects. The orchestra pit should have sufficient duplex outlets to take care of the music racks for the maximum size orchestra. These outlets should be installed in the floor and along the walls in order to eliminate the hazard of portable cables. The circuit will be controlled from the stage switchboard.

Size of the Auditorium

A factor that is often overlooked in the design of an auditorium is the seating capacity. In a commercial field and in other specific situations a design is arranged with the idea that it is necessary to have the entire potential attendance at one performance. The larger the attendance, the less expense involved, the more money made.

However, in an educational situation the auditorium or theater is for an educational purpose, no matter at what level—elementary, secondary, or college—it

is used. A fine program is prepared and, so far as the performance is concerned, there is value in having repeat performances. From this viewpoint it might be logical to reduce the seating capacity of the auditorium or theater and spend some of the limited funds in seeing that the auditorium has better equipment, so that the performances can be presented adequately. Although audio-visual aids can be presented to large massive groups, it is difficult to hold the personal student-teacher relationship that can be attained in smaller groups. This should be considered by school administrators and teachers when building the theater or auditorium.

Public Facilities

A common fault of school auditoriums is that the lavatories and public rooms are often quite a distance from the auditorium. In some instances they are in other parts of the building and are locked, so that there is no access to them during theater performances. The lounge facilities to take care of the public between acts or during intermission should be large enough to be comfortable. These lounges and lobbies may be as luxurious as finances permit, but the ventilating system should be separated from that of the theater proper.

Ventilation

Ventilating an auditorium is a very serious problem. To move 1,800 cubic feet of air per person per hour into an auditorium presents quite an engineering situation. The air cannot be moved more than 300 feet per minute, preferably 250 feet or less, without creating noise, and must be moved much more slowly if there are many obstructions, bends, louvers, etc. Ventilating engineers have many adequate designs; however, in moving air in an auditorium it must be remembered that air of low heat, 75 to 80 degrees, entering the auditorium will normally heat the auditorium to 70 or 75 degrees. Seventy or seventy-five degree air directed in any quantity upon an individual will be uncomfortably cold. Prior to occupancy of the auditorium, the temperature should be lowered two to five degrees. The engineers can give adequate information on these items.

Illustration 28

AIR DUCT ACCOUSTICAL LINING
University of Colorado, Boulder

The air in an auditorium that circulates around the ceiling does not serve the purpose of ventilating and moving air out of the auditorium, nor does it remove the odors and accumulated stale air; therefore, the air must enter at as many outlets as possible and at low levels, and it must move to a number of outlets in the ceiling or high up along the wall. If the engineer so desires, the process can be reversed by pushing hot air in from the ceiling and exhausting it out through many outlets along the floor and walls. The mechanical process of how this is accomplished is the concern of the engineer. The 1,800 cubic feet of air per person per hour mentioned above is still required by many states, although modern ventilating engineers are now recommending considerably less.

The requirements of good ventilation are: to have sufficient fresh air, to remove spent air and odors, to avoid drafts, to have and maintain proper temperatures on the stage and in the auditorium, to avoid transmisison of sound via ventilating ducts, and to move the required air without disturbing noise (300 feet per minute or less). How this is accomplished is the problem of the engineer and architect.

Heating and Conditioning

In the development of modern heating plants there is a definite trend toward air conditioning. Air conditioning means cleaning, purifying, heating or cooling, and ventilating, not cooling alone; that is, bringing in proper proportions of fresh air. Independent air conditioning equipment is the easiest solution to transmission of sound via ventilating ducts. In the past, in a large building heated from one central system, many long ducts had to be installed from a central heating plant capable of taking care of a small room or a large auditorium. These ducts were necessary to reduce the transmission of sound. Many of the duct problems are now eliminated by using independent conditioning systems.

Also in changing the air within the auditorium the change must balance the air changes in the stage area, so that the curtains on the stage do not billow.

In the orchestra pit players must be provided with adequate ventilation and yet slight drafts on instruments can throw them completely out of tune.

Lighting

The lighting in an auditorium does not need to be bright, but it should be placed on dimmers so that the quantity of light can be controlled for different situations. It is necessary to control these lights gradually to indicate intermissions, etc., and to bring the lights on gradually or take them off gradually for better audience comfort. Lighting should be of the type that can be increased or decreased from the stage switchboard or from the back of the house to avoid sudden shock following a dark house. Aisle

lights and exit lights should be constructed so that they will not interfere with the stage effects. Exit lights should be placed in such a manner that they will not interfere with the dramatic lighting of the stage performance. These lights should not interfere with the audience view of the stage.

Sound Reinforcement

In some auditoriums it is practical, or deemed necessary, to reinforce the sound emitting from the stage. A common mistake is to place several high fidelity and powerful speakers next to the proscenium arch. Sometimes these speakers are hidden or placed behind the front teaser or curtains. Other times they are exposed adjacent to the proscenium. Too many times this sound reinforcing merely makes the sound louder rather than reinforcing it. Most sound engineers will concur that a *number* of speakers should be placed *throughout an auditorium* where sound reinforcing is required. In this manner each speaker will reinforce the sound at a normal level. Too often musicians and others think that sound reinforcing merely means to make loud music or loud speech louder, so that those in the front of the theater suffer from the distortion and those in the back can barely hear. With the aforementioned method of using a number of speakers operating at a normal level, a natural effect can be attained.

Acoustical Treatment

The acoustical treatment is definitely the problem of the architect and the acoustical engineer. The purpose is to allow the sound to be transmitted from the stage and pit in a natural and comfortable manner to all parts of the auditorium. Acoustical material may be planned to enhance the beauty of the structure, however, the type of block that is designed for acoustics and not for decoration should be used. The type of acoustical material should be used that will require the least amount of maintenance, and that can be maintained without distorting the acoustical quality.

Illustration 29

CONCERT HALL STAGE
University of Arkansas, Fayetteville

The University of Arkansas Arts Center Concert Hall has a stage large enough to accommodate an orchestra and chorus at the same time. The pipe organ console can be moved to any part of the stage.

VI

Shells

The performance of music outdoors is in most communities handicapped by makeshift platforms and stages, poor acoustics, and crowded or uncomfortable audience conditions. Schools and communities which have found their facilities and opportunities for musical expression limited are giving serious consideration to the erection of school and community shells. For that reason, it has been considered essential to include in this bulletin some examples of shells[4] already constructed or soon to be constructed. In addition, some suggestions are included which should prove helpful to those planning the shell.

If your community needs a "band shell," you will be interested in this report, which can save you and your city planners considerable time, money, and effort in securing the information necessary to launch your project. You will be pleased to learn that one of the most effective shells acoustically is also one of the least expensive to construct.

The first requisite is, of course, community interest in the project. If it is lacking, the following suggestions may prove helpful in developing it:

(1) Discard the term "band shell." Though widely used for outdoor stages, it is an unfortunate nomenclature in that it implies a limited use of the structure. Point out that the shell will be used for a wide variety of community groups, such as local and visiting orchestras, choirs, bands, operettas, plays, dance reviews, ballet, and pageants depicting local, state, or national history. It will also be available as a speakers' platform for national holidays and political campaigns; as a headquarters for certain convention activities; and as a meeting place for school, church, Boy and Girl Scout, fraternal, or other community gatherings which are often too large for an indoor auditorium, especially in warm weather. To this list you can no doubt add other uses adapted to your own community.

(2) To indicate its uses, the term "Fine Arts Community Shell" might be used; "Fine Arts" referring to all the arts of music, drama, dance, speech, and related activities, and "Community" referring to its availablity to the entire community. Citizens may prefer just using the name of the town, as "Bradenville Shell."

The next important step is choice of a site. In choosing a location for the shell, keep in mind that you are not building it for the tourists to see but for the performers and listeners of your community to use. The site should be in a quiet area, free from the noise of automobile traffic, trains, airplanes, boat whistles, etc., and yet easily accessible.

Be sure to avoid a drive-in audience. Parking lots should be distant enough so that cars entering and leaving will not disturb the audience. The site should be as free from the winds as possible. Visibility of the stage will be improved if it is three or four feet above ground level with seating space for the audience on a gentle slope upward from the stage.

Two Problems

There are but two problems to solve in designing a shell: (1) How can sound be most effectively transmitted? (2) How can undesirable noises be eliminated?

Keep in mind that *sound should not be focused*. Instead, *it should be reflected and distributed* to the audience area.

The ellipsoid shell (see Illustration 30) has proved unsatisfactory because it reflects the sound to certain focal points in the audience area, producing a bedlam of noise and destroying the balance of the performing groups. Those sounds nearest the focal lines are overemphasized and those away from them are underemphasized.

The spherical shell is only slightly better than the ellipsoidal; it is unsatisfactory acoustically. While its structure is complicated and costly, it is of less value as a reflector than a simple vertical wall would be.

The parabolic shell causes undesirable reverberations because a portion of the ceiling is parallel to the floor, and sound is thrown down to the first rows of the audience where it is not needed.

The conical section is good acoustically except for the fact that it focuses sound farther along its center axis than to the outer edges of the audience. Also, care must be taken not to get the reflecting surfaces too far from the source of sound. If the audience is seated on a level, the ceiling should be at a 45-degree angle. If the audience is on a slope, add one-half of the angle of the slope to the 45 degrees.

The addition of concentric ridges to the conical section makes it possible to lower the reflecting surfaces so as to be nearer the source of sound and still have the angle of the reflectors in proper relation to the audience. (See Illustration 30.) Its high cost of construction is the only objection to this type of structure.

[4] This section, except for the opening paragraph, is a reprint of an article which appeared in the May-June 1952 issue of *The Instrumentalist*. The original title was "Let's Build More Shells for Community Use," written by Robert S. Meyer with technical assistance by Henry L. Kamphoefner. We are grateful for their permission to use it.

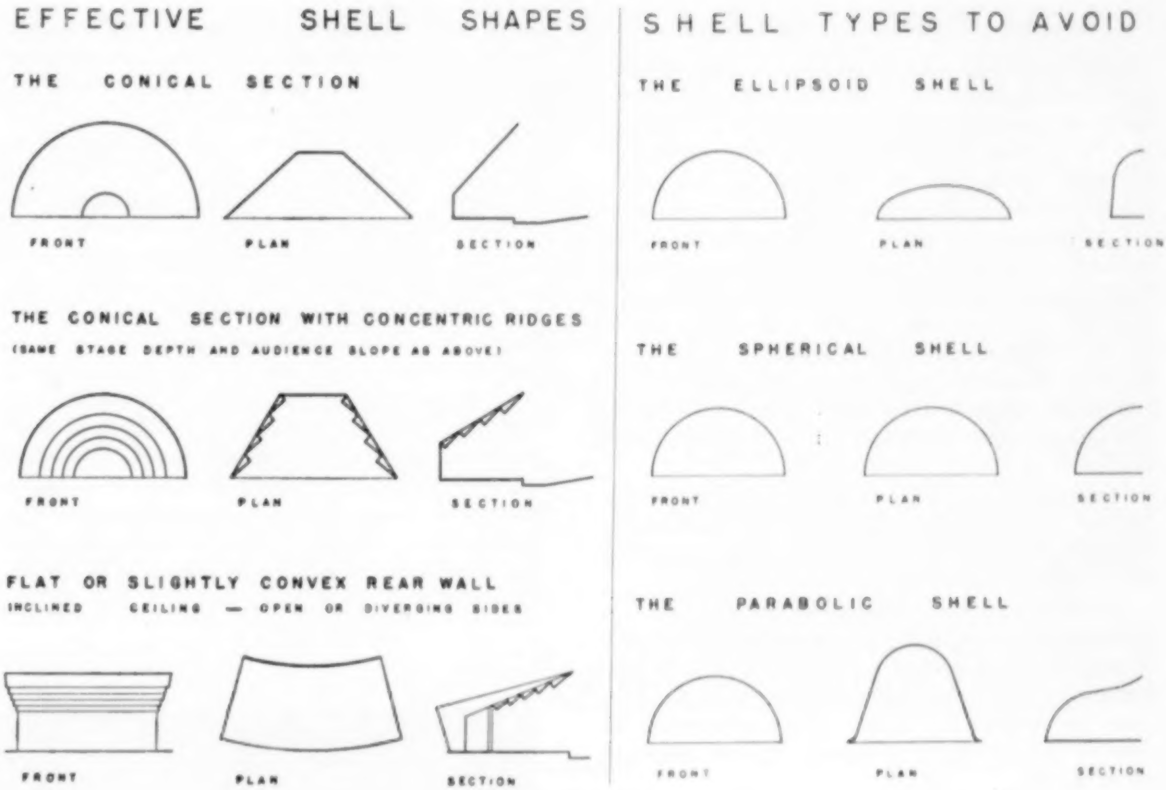


Illustration 30

SHAPES OF SHELLS

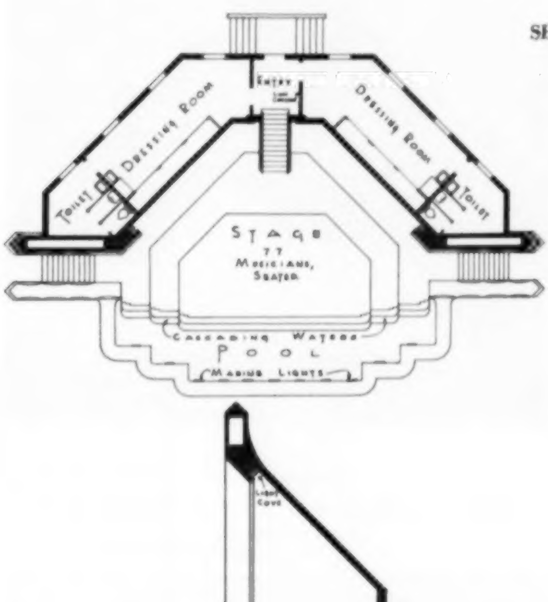


Illustration 31

MUNICIPAL MUSIC PAVILION PLAN, FORT DODGE

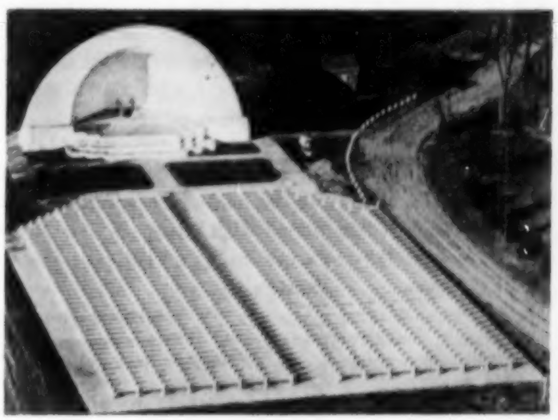


Illustration 32

MUNICIPAL MUSIC PAVILION, FORT DODGE, IOWA

Henry L. Kamphoefner, professor of architecture, University of Oklahoma, has designed many Middle Western band shells, including the well-known structure at Sioux City, Iowa, chosen by the Royal Institute of British Architects as "one of America's distinguished buildings." The picture above and the drawings adjoining show the Fort Dodge, Iowa, music pavilion built in 1938 at a cost of $56,000. (The Sioux City shell, somewhat larger, cost $65,000.) Both are conical sections, adjudged the most perfect type of shell from an acoustical standpoint. Tests made at Fort Dodge showed that the slightest pianissimo could be clearly heard without distortion 600 feet from the stage. Built of poured concrete to last for generations, memorial music pavilions of this type would cost much more today than when the Sioux City and Fort Dodge shells were erected.

Effective and Economical Shell Design

A flat rear wall with a cantilever-supported, inclined ceiling has been found most effective acoustically and also most economical to build. The ceiling may be modified by breaking it up into horizontal reflecting boards that can be adjusted to proper angles to fit the audience level. Substituting a slightly convex rear wall would serve to reflect sound to the sides of the amphitheater as well as to the front. Diverging side walls could be added but would probably add no more than one per cent to the shell's acoustical effectiveness as estimated by Vern O. Knudsen, acoustical engineer of the University of California at Los Angeles. Side walls, it is obvious, would impair visibility from the sides of the audience area.

Financing is one of the most difficult phases of the problem. Properly handled, however, it need not be too much of a burden. Some of the suggestions given below may prove helpful.

(1) Be sure to work through proper channels. Do not incur the displeasure of possible sources of support by not asking them to work with your "shell committee" from the very start. If the town has a planning commission, consult with it concerning the over-all plan of city development, type of materials, location, etc.

(2) Choose a style of architecture whose cost is within reason for your community. Secure the services of an architect to draw sketches of the proposed shell to be used in the campaign for funds.

(3) Finance the shell as a living memorial to those who served their country during a war or as a memorial to a recently deceased public servant or community-minded citizen.

(4) Do not miss any chances to raise money for your project. Some suggestions which would be carried out in the order listed with adequate newspaper and radio publicity and preferably in the same season are as follows:

a. A house-to-house campaign for contributions by an enthusiastic committee well versed in the many uses for the shell and carrying a copy of the architect's sketch.

b. A variety benefit show, running two or three nights of different entertainment on a temporary outdoor stage at the proposed shell site. Possibilities would include short stunts or acts by the different service clubs, fraternal organizations, veterans' groups, Boy Scouts, and Girl Scouts; entertainment groups from the local Y.M.C.A. or city recreation department; music from the municipal band, civic orchestra, local dance bands, barbershoppers, or other adult choral groups, a massed choir from churches, local instrumental and vocal soloists, and school bands, orchestras, and choirs; in short, all those expecting to use the new shell. If desired, participating groups would pay entry fees from which prizes could be granted for the best entertainment of various kinds.

c. A campaign for contributions from local industry and business.

If you have not reached your goal from the three sources above, you should at least have enough to turn over to your city council with the expectation that it would appropriate the balance. (Of course, it would be an ideal situation if your city council would appropriate the entire amount, making benefits and contribution campaigns unnecessary.)

A few examples of shells for your inspection: Ellipsoid shells at Balboa Park, San Diego, California, and Ackley, Iowa; spherical shells at Spreckles Music Pavilion, Golden Gate Park, San Francisco, California, at Clifton Park Pavilion, Baltimore, Maryland, and Highland Park Shell at Albuquerque, New Mexico; conical section shells at Music Pavilion, Fort Dodge, Iowa, and Grandview Music Pavilion, Sioux City, Iowa; conical section with concentric ridges at Blatz Music Pavilion, Milwaukee, Wisconsin, Grant Park Shell, Chicago, Illinois, and Hollywood Bowl, Hollywood, California; flat rear wall and inclined ceiling at Dow Shell, Midland, Michigan, Port Huron Shell, Port Huron, Michigan, Ravinia Park Pavilion, Ravinia Park, Illinois, Watergate Symphony Shell, Washington, D. C., and the band shell at Waukegan, Illinois.

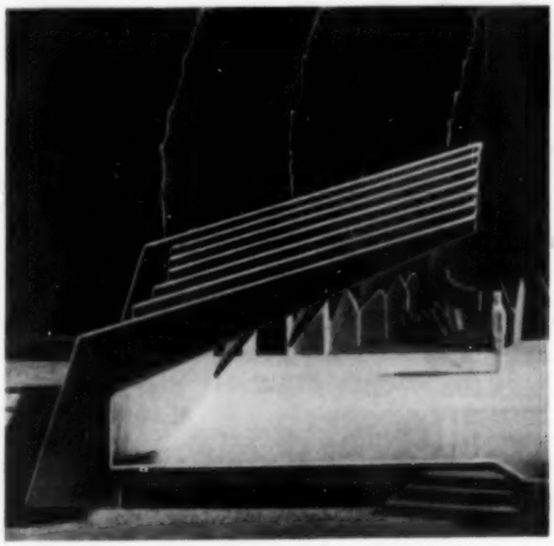


Illustration 33

MUSIC PAVILION FOR A SMALL COMMUNITY
Artist's Sketch

The sketch above shows a miniature model and floor plan of an experimental music shell designed by Henry L. Kamphoefner, easy and inexpensive to build, yet ideal for bands and orchestras of from thirty to fifty pieces and audiences up to 3,000 people. Instead of the traditional conical section construction, which tends to intensify sound along the center axis of the audience area, this pavilion employs a convex or reverse curve vertical wall and slanting fins in the ceiling to reflect and spread the sound striking them to the sides of the audience amphitheatre. The angle of the fins should be adjusted carefully in relation to the slope of the audience area, and the ceiling should be low enough to avoid the echo which results from a high ceiling too far from the source of sound. With cantilever of poured concrete, this type of shell can be built for approximately $12,000.

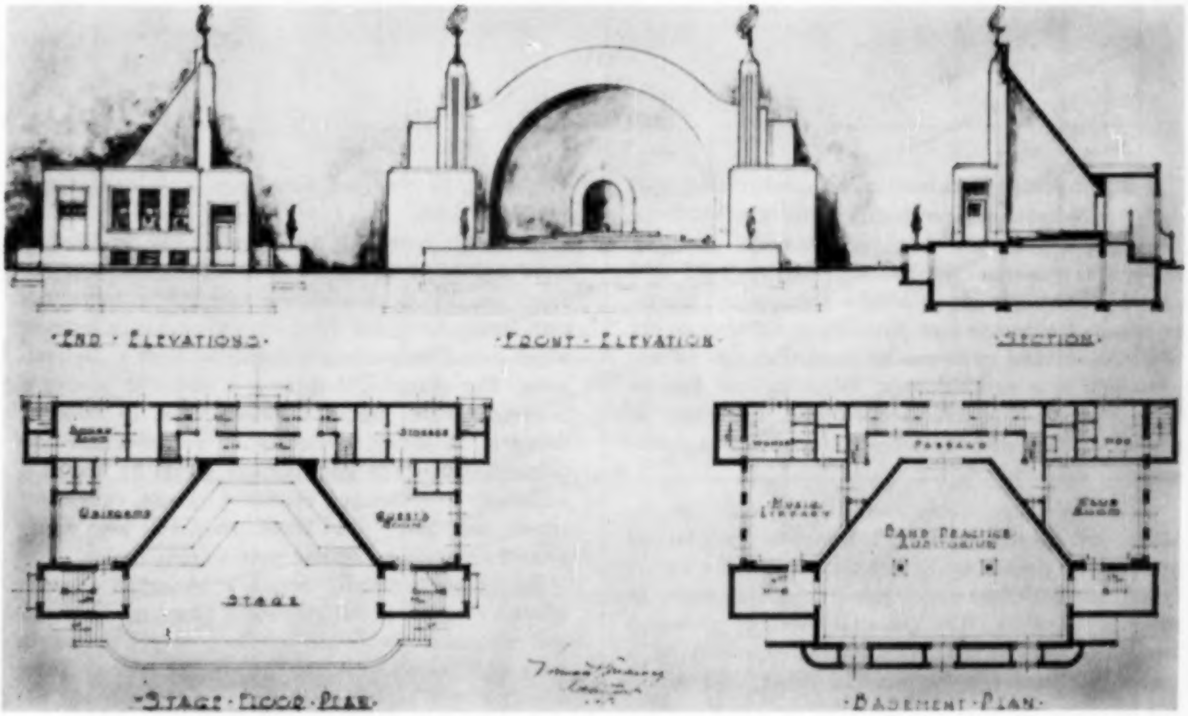


Illustration 34

DESIGN FOR A PROPOSED BAND SHELL

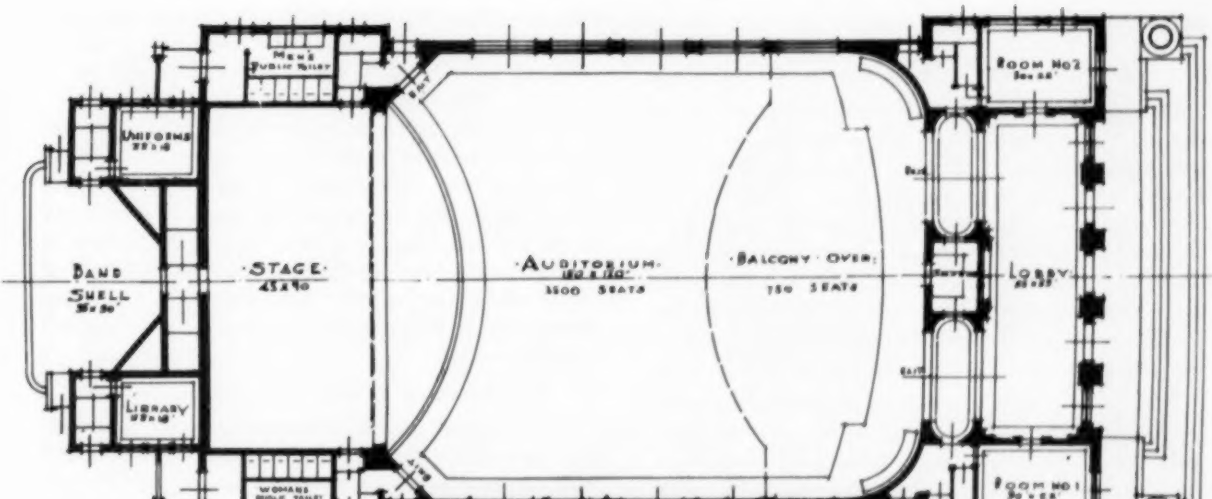


Illustration 35

PLAN FOR A MUNICIPAL MUSIC PAVILION

The lower floor of this type of pavilion could include facilities for banquets, swimming, hobby and craft rooms, and other non-musical activities. Beneath the stage or in the wings space is available for a band rehearsal room, music library, storage space for instruments and uniforms, and dressing rooms.

VII

Acoustics

Acoustics, like illumination, air conditioning, and structural engineering, is an integral attribute of a building.[5] At each stage of planning there are acoustical problems to be analyzed and solved. The same basic principles are involved whether we are planning a new building or altering an old one. All of the problems of acoustics can be approached in a rational way, following the general lines presented in this section and referring, as needed, to specialized technical information or assistance.

As in any engineering specialty, some of the detailed procedures require mathematical calculations and knowledgeable use of technical data. The underlying concepts of acoustics, however, can be stated in everyday English. The essential ideas as presented here will seem intuitively obvious, especially to a person with some background in music. Where the use of numbers becomes essential, as in discussing the *amount* of reverberation or the *degree* of noise isolation, we have used nothing more complicated than grade-school arithmetic. When he has assimilated the meaning of this section the reader will be in a good position to guide the acoustical planning of music rooms and buildings. His efforts, appropriately supplemented by the architect and builder, will be amply repaid in acoustical satisfaction.

The Role of Acoustics in Music Rooms and Buildings

There can be no full enjoyment or appraisal of musical performance unless the sound can be heard with some measure of fidelity. Satisfactory acoustics is more than providing a musical performance space free from obvious acoustic faults; and it is more than isolating sound from persons in surrounding spaces where the sound is not desired. The acoustic properties of a room can enhance the quality of music for the listener, and can give the performer a sense of support which adds to the pleasure of performance.

In order to achieve the best results which acoustical science is capable of providing today, we must integrate the acoustics with the other aspects of architectural design, engineering, and construction. If acoustical control is applied to a completed building as an after-thought, the results are frequently inferior and the cost is usually greater than necessary. On the other hand, if the technical requirements for good acoustics are incorporated into the planning and engineering of the building in a logical way, excellent results can be obtained, sometimes with little if any additional cost.

Let us illustrate this last point briefly. If there is some possibility of alternatives in the planning, as there usually is, one should attempt to segregate, both horizontally and vertically, those rooms between which sound transmission should be kept to a minimum. For example, if there is a choice of placing a bandroom either under a lecture room or under a cafeteria, it should obviously be placed under the cafeteria where the band sounds would be less of a nuisance. Furthermore, corridors, closets, equipment spaces, and other "dead areas" should be used where possible as buffers against sound transmission.

As for construction, there are numerous cases in which two possible wall types are about equal in cost and structural properties but are very different in their abilities to block the passage of sound. Thus, a wall of two relatively thin leaves of plastered tile or wood-stud construction separated by a small air space is generally more effective than a single-leaf wall of the same weight or thickness. In the interior finishes and furnishings, also, one is frequently able to make selections which aid the acoustics. Thin plywood paneling properly applied can provide useful sound absorption in a room. (See footnote to Illustration 43 regarding thin wood paneling). Carpets, draperies, upholstered seats, and other soft furnishings can be selected to serve acoustics as well as to perform other functions.

Briefly then, acoustics plays the role of an essential functional element in the design and construction of music buildings. The location of the site, the plan of the building, and the arrangement of its spaces, the gross and fine features of room shape, the structural materials and their methods of use, the detailing of doors and windows, the characteristics of interior finishes and furnishings—all these may influence acoustic design.

Problems and Criteria of Acoustic Control

Architectural acoustics has two general purposes: (1) to provide a satisfactory acoustic environment, and (2) to provide good hearing conditions. Though the achievement of these two aims sometimes involves similar techniques, there are significant differences between them. Since both types of problem are involved in music buildings, it is important that we understand clearly these distinctions.

Acoustic Environment

The acoustic environment of a given space is determined by (a) the intensity and character of all

[5] This section was prepared by Richard Bolt, head of the Acoustics Laboratory, Massachusetts Institute of Technology, Cambridge.

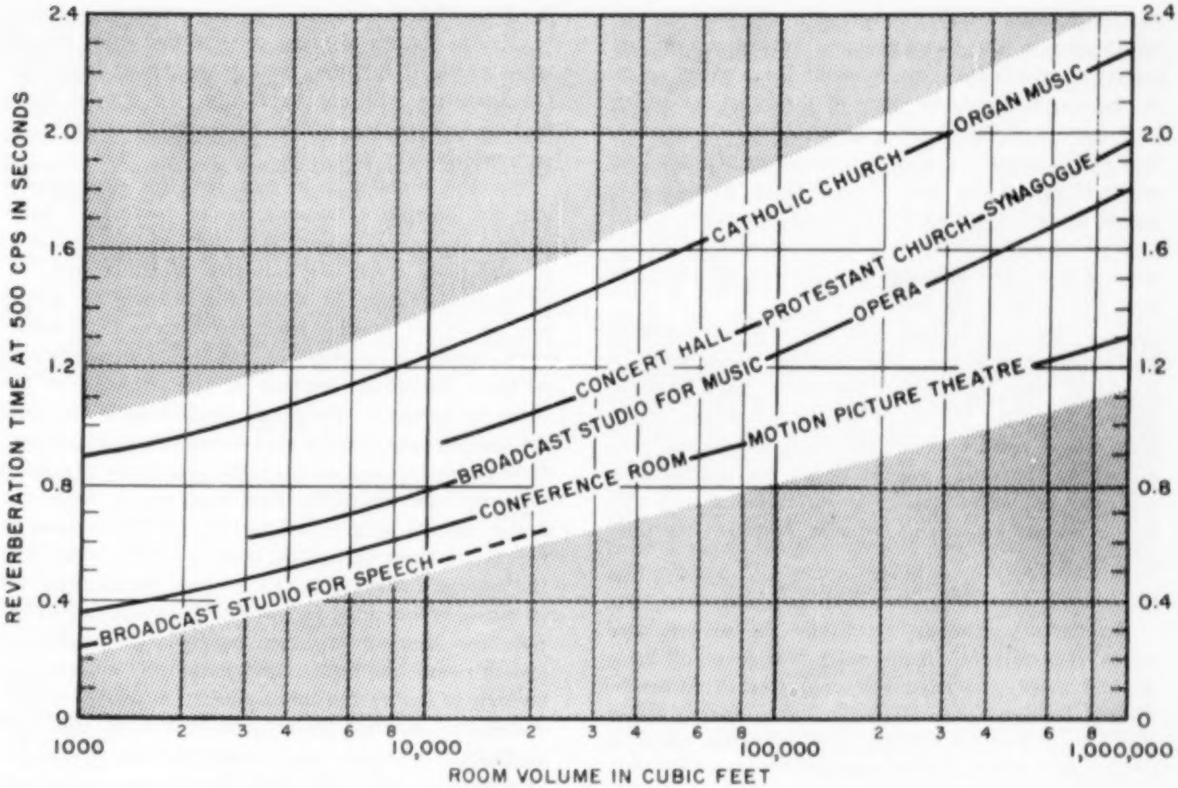


Illustration 36

OPTIMUM REVERBERATION TIME FOR ROOM OF VARIOUS SIZES

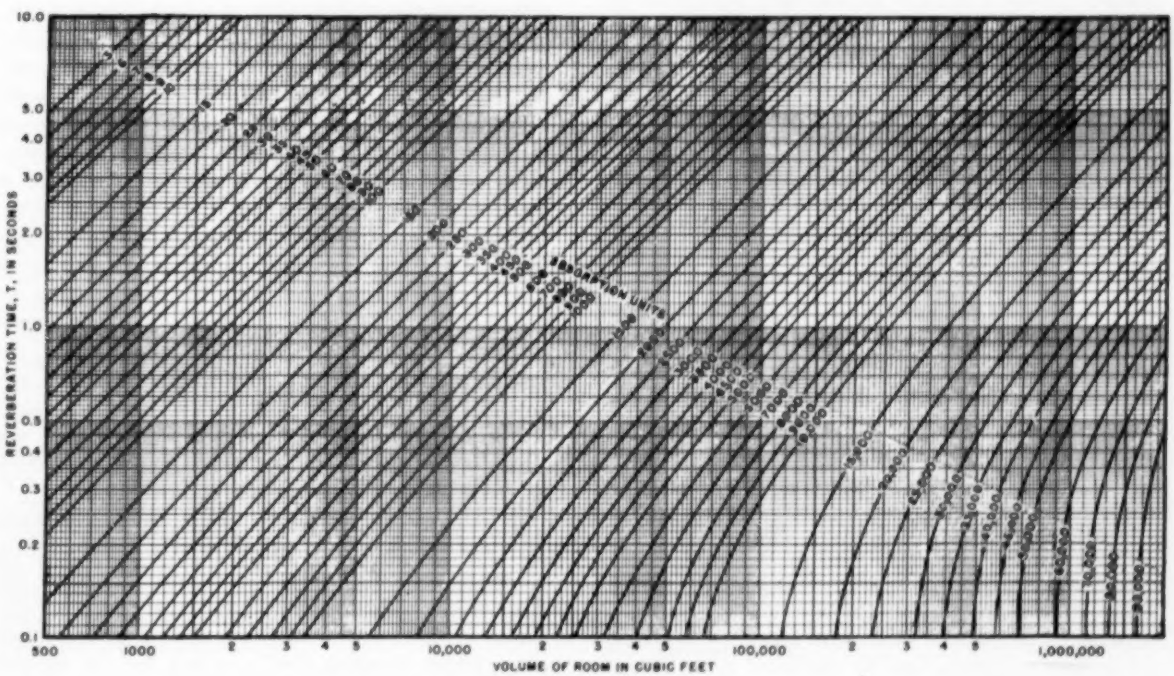


Illustration 37

RELATION BETWEEN REVERBERATION TIME, VOLUME AND NUMBER OF ABSORPTION UNITS IN SABINS

sounds existing in that space, and (b) the way in which sounds are prolonged and spread within the space. A satisfactory environment for a given space can be specified only in terms of the functions which that space is to serve. In a hospital room a satisfactory environment requires the reduction of intruding noises to a very low level. In a factory, considerably higher noise levels may be tolerated, but there is still a more or less definite maximum beyond which increased noise will influence the comfort, efficiency, or even the health of the workers.

In a music building, the acoustic environment problems are multiple. The practice rooms must be insulated from one another and from other building noises. In turn, there are the libraries and study halls which must be insulated from the sounds generated by the music rooms, shops, air conditioning systems, and cafeterias. The cafeterias should also have a certain amount of acoustic treatment for their own sake.

Hearing Conditions

Satisfactory hearing conditions in an enclosed space require: (a) Sufficiently low level of background noise; (b) adequate separation of successive sounds (reverberation control); (c) proper distribution of sound within the space; (d) sufficient loudness of sounds which are to be heard.

Background noises, composed of the sound transmitted from outside the room and incidental sounds generated within the room, have to be kept to a certain minimum in order to obtain good hearing conditions. There must also be *adequate separation* of successive sounds in the room, both for music and for speech, since too much reverberation causes undesirable blurring. However, a certain amount of reverberation is required to aid in blending music and reinforcing speech. It is desirable to have uniform quality everywhere in the room. A music room should be so constructed that the sound will be *properly distributed* without regions of confusion, echoes, or focusing at any point. The sound must be *sufficiently loud* to be heard easily and intelligibly in order that even the *softest* passages of music may be appreciated. As a rule, this need for loudness poses no problem in small music rooms, but a large auditorium requires a specially designed stage (orchestra shell), and it may need an amplifying system, particularly for solo work.

Acoustic Criteria

Each of the conditions specified above for satisfactory environment and good hearing is subject to certain more or less definite design objectives or criteria. Some of these criteria have been reduced to formulas and charts and can be given with a reasonable degree of accuracy. Others can be expressed only in general terms, and we are subject to interpretation on the basis of background knowledge and experience in the field of acoustics. In this discussion we indicate briefly the nature of these criteria and give general rules which, if followed, will guarantee at least that the acoustics will not be faulty. In special cases further information will be necessary in order to insure satisfactory acoustics.

The first problem to be met, both for environment and for hearing conditions, is *the control of background noise*. Some criteria for acceptable background noise levels are indicated in Illustration 38. In general, rooms in which the hearing of speech and music are primary functions have more stringent requirements than those in which one simply wants to have reasonable comfort in the presence of the noise background. Broadcast studios have the most critical requirement, for even a small amount of interfering noise is very undesirable in a radio broadcast program. In an auditorium a person is somewhat better able to ignore such sounds, partly because he recognizes them as coming from a source other than the musical instruments. In general, the sound levels in music rooms must be low enough so as not to impair the hearing of quiet passages of music. In speech rooms, the background noise level must be low enough to insure the intelligibility of spoken words. Actually, somewhat lower levels than those indicated in Table I for speech are preferable; even though the background noise is so low that it does not impair intelligibility, the intrusion of the noise may be a distracting element.

The next problem is *reverberation control*, by which the separation of successive sounds is influenced. Reverberation, the prolongation of sound after a source is stopped, is specified by *reverberation time:* the time in seconds for the sound to die away to one millionth of its initial intensity. For a given size of room and condition of use, there is an optimum range of values for reverberation time. In general, a large room requires a longer reverberation time than a small room, and music sounds need a longer reverberation time than speech sounds. It is also interesting to note that organ and oratorio music call for a longer reverberation time than, for example, solo or chamber music. In fact, the building which houses an organ is really part of the instrument, and the reverberant characteristics of such buildings have historically influenced the composition of organ music. These criteria for optimum reverberation time are given in Illustration 39, and are discussed more fully in the later section on reverberation control.

A satisfactory acoustic environment also requires that the reverberation time lie within certain limits, although these limits are less critical than those for hearing speech and music. If sufficient absorbing material is introduced to give the room a reverberation time which is about that specified for the speech-hearing conditions in Illustration 36, the room will be reasonably comfortable for most conditions of use.

In almost all cases, a room which has more than three times this value of reverberation time will be uncomfortably reverberant. Where extreme quiet is desired, as in a library or lounge, a reverberation time as low as one-half the optimum for speech may be desired. However, if a room is deader than this, it may create an unnatural or oppressive feeling.

The requirements for proper distribution can be loosely summed up in the statement that sound should be uniformly diffused throughout the listening room for satisfactory hearing conditions. The room should be free from distinct echoes and focusing effects; there should be no regions of confusion which might arise from interferences among the sounds. In larger rooms, it is important to direct the sounds from the stage in such a way as to reinforce them at the more distant parts of the room. The criteria for proper distribution cannot be stated in simple numbers, but can be discussed in a general way, as will be done in a following discussion of *distribution control*.

Illustration 38

Generally Acceptable Criteria For Maximum Background Noise

Function	*Average Noise Level* In Decibels
Radio studios	25-35
Auditoriums for music	30-40
Small auditoriums for speech or large auditoriums with amplified speech	35-45
Libraries and offices for concentrated study	35-50
General offices	40-60
Factories and shops (depending widely on type of activity)	50-80

Any noise levels less than those indicated are, of course, acceptable and desirable. The range of values shown for each case indicates results generally achieved in good acoustic practice. Also, this range represents some leeway depending on the specific use or characteristics of the room.

Sufficient loudness of sounds is obviously necessary if one is not to lose some of their quality or intelligence. In moderate-sized rooms of up to 50,000 cubic feet or so, the problem of loudness does not pose serious difficulties. If the room is reasonably well shaped for good distribution, loudness will be adequate for hearing both music and speech. For rooms much larger than this, and generally for rooms of more than 250,000 cubic feet, it becomes necessary to reinforce speech by the use of a public address system (microphone, amplifier, and loud speaker). Even though an orator can make himself heard in a larger auditorium, it requires excessive effort; speakers with weak voices or little training would find the task virtually impossible. With the best public address systems of today it is unnecessary to subject speakers to these difficulties.

The problem is somewhat different in the case of music. Even a very large hall, of a million cubic feet or more, may be satisfactory for symphonic music if the background noise is extremely low. However, intruding noises from traffic may drown out the softer passages of music. This effect can be readily observed in some halls by listening first at the front of the auditorium and then at the back where the music sounds are weaker. Solo voices and instruments particularly need assistance. For these cases, proper shaping of the areas around the stage is of utmost importance.

If a public address system is contemplated, it should be integrated into the design of the room allowing for optimum location and orientation of the loudspeaker system.[6] Amplification of sound in auditoriums involves specialized engineering procedures and criteria which are beyond the scope of this chapter. From the user's point of view, however, a satisfactory public address installation is one which provides a listener at any position in the auditorium with a satisfactory degree of loudness, naturalness, and fidelity. The sound should *seem* to come from its original source and should not seem to be artificially reinforced.

Sound Isolation

Sound isolation is achieved through proper planning to segregate sounds, and, through proper design of building structures, to block effectively the passage of sounds. The total degree of noise reduction between two spaces is further influenced by the presence of sound absorbing materials which reduce the amount of sound energy present. Briefly, segregation reduces the effects of noise by getting farther away from it; insulation reduces noise by presenting a barrier against its passage; absorption reduces noise by draining off sound energy. Mathematical statements of these effects are complicated, but basically the equations merely express what one would expect intuitively: noise reduction increases with the distance of separation, with the insulating value of the structure (usually expressed as *transmission loss* of a given wall panel), and with the amount of absorption in the room (expressed in *absorptive units* or sabins). Segregation and insulation will now be discussed; absorption will be dealt with in subsequent paragraphs.

The acoustic design of a music building should commence with a careful functional analysis of all spaces contiguous to the music rooms. This analysis should include a listing of all types of activity which may be encountered in these spaces as well as a study of their schedules of use. Thus, if a band teacher's office is never to be used for quiet study while the band is performing, there is no need to take special precautions to sound-insulate the office, particularly if additional expense would result.

[6] Contrary to common practice, it is usually best to use a *single* loudspeaker assembly, centered above the stage proscenium; the use of two speakers, one on each side of the stage, should be resisted adamantly.

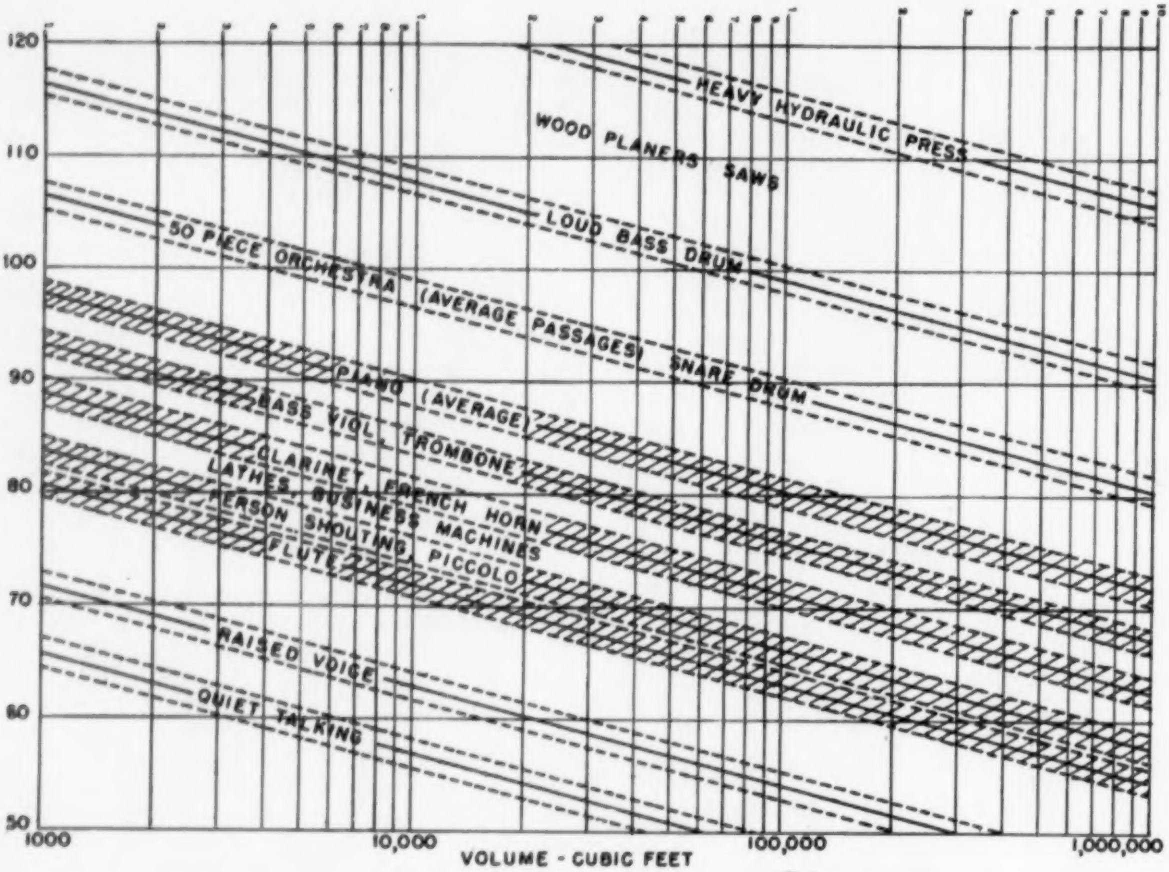


Illustration 39

SOUND LEVEL—DB (Adjusted for Optimum Reverberation Time)

Compromises in planning will sometimes be necessary because of economic or other factors. All such compromises should be clearly recognized and stated at an early stage of the analysis. As an example, it may be essential to group a large number of piano practice rooms side by side along a corridor. Since these rooms have common walls and since very high noise levels are generated by pianos, transmission of sound between adjacent rooms can be kept at a very low value only by extremely costly construction. Under such conditions the school might have to decide to subject the students to a certain amount of "noise" during their practice, although this compromise should not be accepted before all possibilities of rearranging have been explored.

Estimation of Allowable Background Sound Levels (SL_a)

The noise levels listed in Illustration 38 represent an estimate of background noise allowable, and are the values which one would read on a sound-level meter. The meter must meet the specifications of the American Standards Association[7] and be used in accordance with standardized procedures. The numbers given in Illustration 38 are those which would be obtained when using the appropriate "weighing network"; that is, the forty decibel, the seventy decibel, or the flat network, depending on the sound level involved.[8] The limits listed in Illustration 38 will vary somewhat, depending upon the character of the sound and the psychological differences among listeners. However, there is general agreement on acceptable ranges of interfering noise level for various types of activity as given.

If the interfering sounds that enter into the acoustic analysis of a music building are the "usual" kind (traffic noise, speech, more or less steady passages of music, and so forth) the information in Illustration 38 and the standard sound level meter may be used as reliable guides. For the highly percussive sounds of certain musical instruments and for the very low frequency of the timpani, a special study may be required. In general, it is more difficult to isolate against such sounds; hence, it is frequently necessary to accept a compromise, allowing percussive and very low frequency sounds to be heard in adjacent spaces but confining the general sounds of music to the performance room.

[7] American Standards Association Publications Z24.2, 1942 and Z24.3, 1943.

[8] See the *Noise Primer*, General Radio Company, Cambridge 29, Massachusetts.

Estimation of Source Sound Levels (SL_s)

Some information on sound sources is given in Illustration 39 and discussed briefly here as a general guide to acoustic planning. The present discussion is aimed to provide an orientation on the relative magnitude and importance of isolation problems commonly met in practice.

Illustration 39 gives, for a number of typical sources, the average sound levels in decibels as a function of the size of the room in which the source is situated. Several simplifying assumptions are involved. First, and perhaps most important, any given source may generate sounds over a wide range of levels. Orchestral sound, for example, may run from ten to thirty decibels above or below its average level during fortissimo or pianissimo passages, respectively. As a consequence, a reasonable compromise in engineering design may allow occasional passages to be heard in other rooms in the building even though most of the sounds are effectively isolated.

A second consideration to be taken into account in interpreting Illustration 39 is that the sound level is not usually uniform throughout a room, but may differ by ten or twenty decibels from point to point. This variation will be minimized by proper design of the room to provide sound diffusion and reinforcement at room positions remote from the source.

Again, the reverberation characteristics of a room influence the sound levels produced in it. A given instrument in a room of given size generates lower sound levels as the reverberation is decreased by the introduction of additional absorbing material. Illustration 39 is based on rooms adjusted for optimum reverberation time in accordance with Illustration 36. Each source in Illustration 39 covers a band about three decibels wide, corresponding approximately to the range of optimum reverberation times specified in Illustration 39. If the source is in a room with greater than optimum reverberation, its sound level will be correspondingly greater.

Finally, the frequency characteristic (tone quality and pitch) of sound sources are neglected in Illustrtion 39; only the average value over all audible frequencies is given. If a source predominates in low frequencies, e.g., the base drum, special attention must be given to the low frequency characteristics of materials to absorb this sound or walls to block its passage.

The Noise Reduction (NR)

The difference between the source sound level of intruding noises and the acceptable sound level for satisfactory acoustics in a room is commonly expressed by the *noise reduction*.

$$(1)\quad \text{NR equals } SL_s - SL_a$$

The NR is thus a measure of the total reduction in sound which passes from one space to another. If the traffic noise surrounding a building has a value SL_s equals 80 db, and if an interior value SL_a equals 35 db is desired, the building as a whole must provide an NR equals 45 db. If with this value of NR the exterior noise should now rise to 100 db (as by aircraft overhead) the interior sound level would be 55 db. The NR is a constant for a given building situation and does not depend on the intensity of the sound source.

The NR between two existing rooms may be determined by generating a steady sound in one room, measuring the sound level in each room by using a sound level meter, and taking the difference. The NR is the same in either direction, as can be verified by putting the source first in one room and then the other.

Estimation of Transmission Loss (TL) Required For Construction

The noise reduction between two spaces depends primarily on three things: (1) the insulating value of *transmission loss* (TL in decibels) of the entire intervening structure (walls, floors, ceilings, doors, windows); (2) the area of these elements which are common to the two spaces; and (3) the amount of absorption in the room which is to be protected against received sounds. The contribution of these three elements can be expressed by the equation:

$$(2)\quad SL_s - SL_a = NR = TL + AG - AL$$

Here AG is the *area gain* which increases with the sound-transmitting area in the manner shown by Illustration 36. Obviously, more sound passes through a large wall than through a small one if the sound level is the same over all parts of the wall surface. The quantity AL is the *absorption loss* which increases with the amount of absorption in the receiving room. Values of AL as a function of room volume are given in Illustration 41 for rooms which have been adjusted to have optimum reverberation time.

For calculating the required transmission loss, equation (2) may be written as:

$$(3)\quad TL = NR + AL - AG$$

As an example, consider the following conditions:

Room A, 8 × 12 × 15 ft., for piano practice.
Room B, 8 × 15 × 20 ft., for speech class.
Common wall area 8 × 15 = 120 sq. ft.
No sounds enter B except from A through common wall.
Both rooms treated for optimum reverberation.
Required: Satisfactory noise control for Room B.

First, from Illustration 41 we select $SL_a = 40$ db as a satisfactory allowable background. Then using the volume of room A which is 1,440 cubic feet, we see from Illustration 39 that a piano will have an average value of $SL_s = 96$ db. Therefore, the required NR = 96 — 40 = 56 db. By Illustration 40 the transmitting area of 120 square feet gives: AG = 21 db. Room B has a volume of 2,400 cubic feet. So, by Illustration 41, AL = 23 db if the reverberation is optimum for speech. Then TL = 56 + 21 — 23 = 54 db. This is the required transmission loss for the common wall.

Most problems are considerably more complicated than this example, and require a more elaborate engineering analysis than that described by the present charts and discussion. These complications may include multiple noise sources instead of one, non-uniform properties of the intervening structure, and unusual frequency characteristics of the source noise. However, this presentation introduces the basic problems and the general method of attack.

The logical sequence of steps in a noise control analysis is to be stressed particularly. There is little point in discussing "double walls" or "soundproof doors"[9] for a building before thought has been given to functional requirements, schedules of use, planning possibilities, likely sources of noise intrusion, and properties of specific rooms. Having reached this point, at least in our introductory manner, we are now ready to turn to the specific problem of selecting suitable structures, materials, and building details to achieve the required noise isolation.

Sound Insulation Values of Structures

Consider first the simple case in which all the sound passing from one space to another is transmitted through a simple wall of uniform construction over its entire area. Such was the case in the illustrative example given on page 37, where a transmission loss of fifty-four decibels was found to be needed. Illustration 37 shows diagrammatically what this means in terms of wall construction.

In Illustration 42, several basic types of walls are illustrated and are arranged according to their transmission loss value. In a general way, the TL increases as the wall becomes heavier and more complex. Unfortunately, the cost also generally increases, so that economic compromises often become necessary. When high insulation is desired, as it frequently is in music buildings, a variety of possible alternate constructions should be explored with the architect or builder. Such a study should be guided by detailed and reliable information on sound insulation values.[10]

A homogeneous wall increases in TL as its weight increases. For brick, concrete, and solid tile walls the TL increases about 5 decibels each time the weight is doubled, approximate values being 40 db for two-inch thickness, 45 db for four-inch, and 50 db for eight-inch. To achieve values above 50 db, it is usually more economical to split the wall into two or more independent leaves. Thus splitting an eight-inch concrete block wall into two four-inch leaves with four-

[9] A commonly misused term, since no structural element is truly soundproof.

[10] See, for example, *Architectural Acoustics*, Vern O. Knudsen, John Wiley and Sons, Inc., New York 1932; *Building Materials and Structures*, Report BMS-17, National Bureau of Standards, U. S. Government Printing Office, Washington, D. C., 1939.

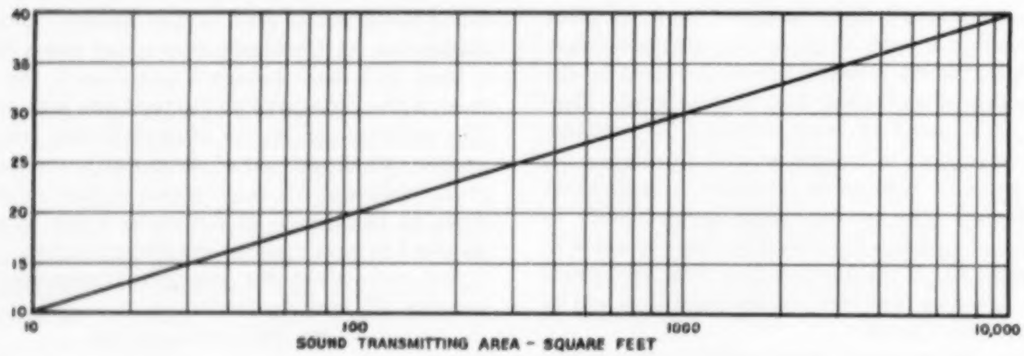


Illustration 40

AREA GAIN—DB

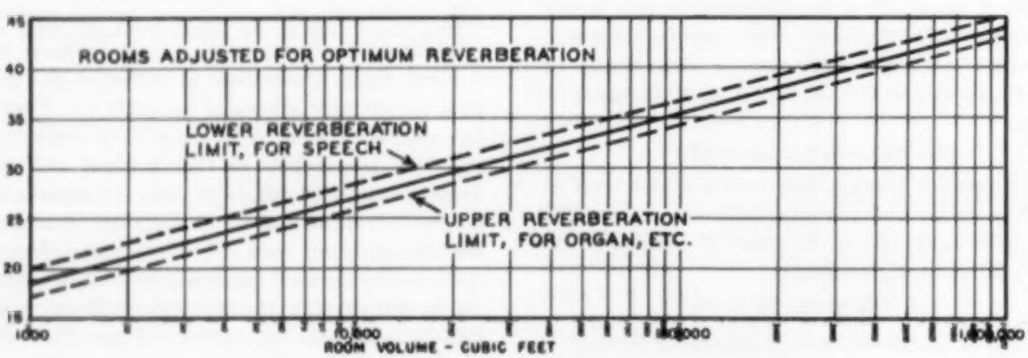


Illustration 41

ABSORPTION LOSS—DB

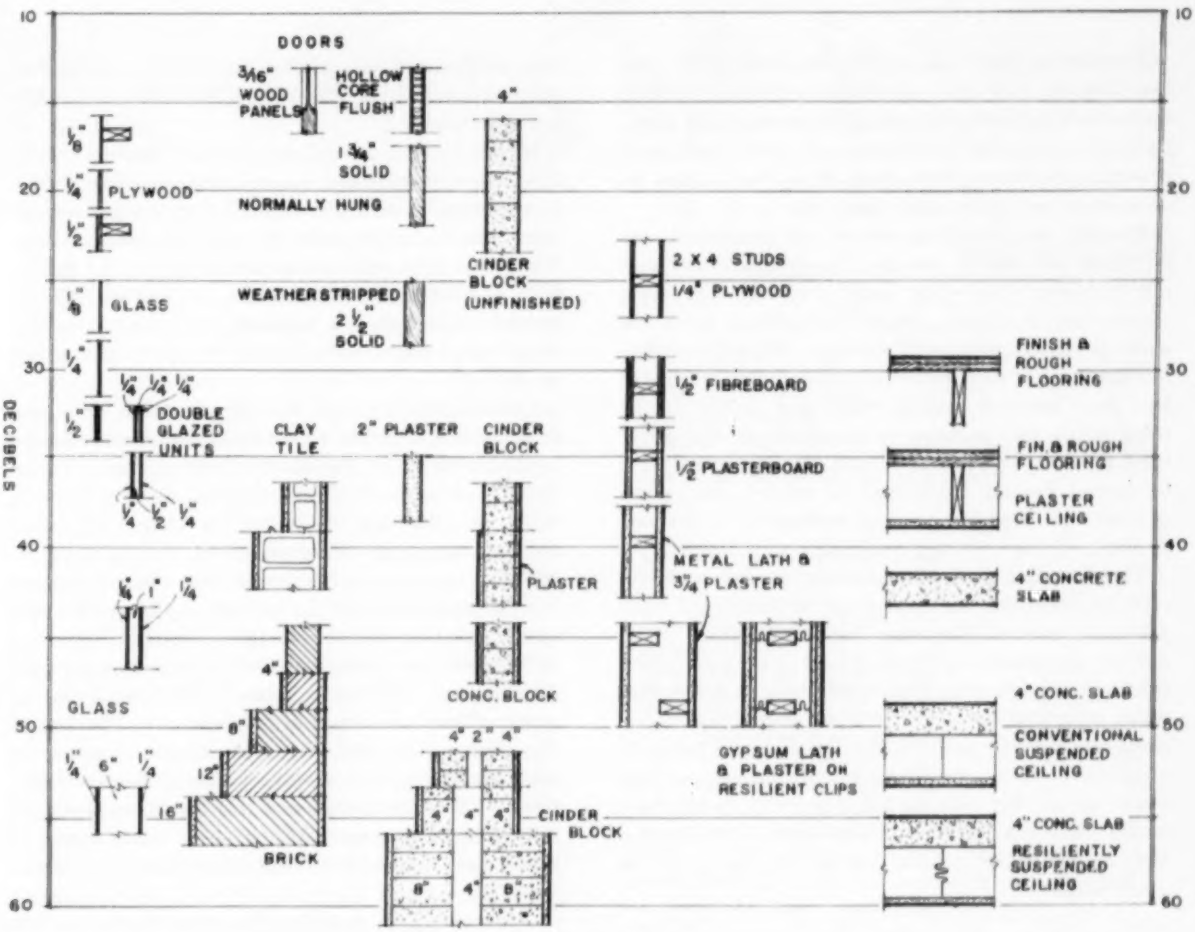


Illustration 42

AVERAGE TRANSMISSION LOSS FOR TYPICAL CONSTRUCTION

inch air space between yields about 50 db, which is even more than would be obtained from a solid wall of the same twelve-inch total thickness.

Stud construction with wood or plaster facings shows similar properties. As long as two faces are rigidly tied together, their TL increases regularly with weight; in this case some 5 to 7 db for each doubling in weight. But when the two faces are structurally separated, on separate rows of studs, the TL increases beyond that expected from weight alone.

In all cases, the values discussed here and those indicated in Illustration 42 will be obtained only if the wall is completely tight against air leaks. Thus, porous blocks are poor insulators when bare, but insulate more or less according to their weight when their faces are tightly sealed with plaster. Any cracks which develop in a wall greatly reduce its insulation value.

A somewhat more complicated situation arises when the sound transmission is not restricted to a single uniform wall. There may be a door in the wall, for example. If this door has the same TL as has the wall, the problem is acoustically equivalent to the uniform case. But it is usually more costly to achieve high TL in a door than in a wall. Lower values frequently can be tolerated, however, if the door occupies only a small fraction of the wall area. Thus, if the door occupies ten per cent of the wall and its TL is 10 db less than that of the wall, it will reduce the over-all effectiveness of the wall by only 3 db; a 40 db door in a 50 db wall would net 47 db for the partition as a whole.

Actually, a 40 db door is a very special one designed for high sound insulation. It is probably three inches thick, with heavy laminated construction set against tightly fitting rubber seals, and hardware to ensure tight closure. Even a 30 db door is not an ordinary one. Several satisfactory sound-insulating doors are available from manufacturers who can also supply information on TL values.

Windows present a similar problem in that ordinary windows have low insulation. Heavy plate glass and even multiple panes (separated like the double wall discussed above) are needed for TL values in excess of 35 db. Of course, the glass must be tightly sealed in its frame.

Ventilating ducts also carry sound effectively unless they are lined with absorbing material. Several commercial products are available to meet this need. Both noise from the ventilating equipment and noise entering the duct system from other rooms must be adequately controlled (see page 26).

Finally, we should be aware of structure-borne vibration and impact sounds. Heavy machinery rigidly mounted to a floor may send out vibrations which travel to remote parts of the building and cause walls to radiate sounds into rooms. Vibration isolating mounts are then called for. Footfalls on a hard, bare floor generate sounds which pass readily to the room below and perhaps to remote rooms by structural transmission. Carpets, cork or soft rubber pads, or special floating floors may be needed, the extent of treatment depending on the stringency of the particular requirements for acceptable sound levels.

The preceding discussion of sound insulation should serve to emphasize the importance of functional analysis and careful planning for segregation. It is difficult and costly to obtain 60 db in a single partition but easy to obtain this reduction through two walls separated by a corridor or storage space. A classroom directly under a band room could be made quiet only by a complicated multiple ceiling-floor construction; but putting a locker room under there would solve the problem without structural elaboration. *Good sound control cannot be put in as an afterthought.*

Sound Absorption—Reverberation Control

The second requirement for good hearing conditions concerns the prolongation of sound in a room after the source has stopped emitting sound. This characteristic, known as reverberation, has been studied extensively, and equations are available for predicting the amount of reverberation which will exist in a room of specified physical characteristics.

More specifically, the *reverberation time* is defined as the length of time in seconds taken for a sound to die away, or decay, to one-millionth of its initial intensity in a room. This reduction in intensity is equivalent to a reduction of 60 decibels in sound intensity level. Since sounds of different frequencies may decay at different rates, the average reverberation time for sounds is usually specified at several different frequencies. Although the lower and upper limits of hearing are approximately 20 and 20,000 cycles per second, only a fraction of this range need be given specific attention in acoustic design. This is partly because most of the important sounds in music and speech lie within a confined region, and also because the ear is more sensitive in the middle range of frequencies than it is at very high and very low frequencies.

It is common practice in architectural acoustics to analyze reverberation at 500 cycles per second as a first approximation, and then to consider a few other frequencies such as 125, 250, 1,000, 2,000 and 4,000 cycles per second.[11]

If one is considering only speech hearing conditions the reverberation control may be restricted to frequencies between 250 and 2,000 cycles per second since this covers the essential range for intelligibility. For music, however, frequencies as low as 125 and as high as 4,000 cycles per second must be included. In special cases, such as a high fidelity radio studio, one might also refine the design at 8,000 cycles per second or higher.

Quantitative criteria for reverberation time are fairly well established today in a manner summarized in Illustration 38. In this illustration, reverberation time in seconds is plotted against room volume in cubic feet. The size of a room has a major influence on the amount of the reverberation found to be desirable. In general, the larger the room, the more reverberant it should be to have optimum hearing conditions. In addition to this variation, there are differences between music and speech hearing conditions, and differences among different types of music. These variations are indicated in Illustration 38. For a given size of a room, speech requires the least amount of reverberation (the "deadest" condition). Chamber music and solo instruments require somewhat more reverberation, and organ music is most pleasing in a room which has considerable reverberation.

Fortunately, these differences depending on use are not extremely critical, so that it is possible to have a compromise in a given room which is reasonably satisfactory for speech and for music. If the room is quite large, say 50,000 cubic feet or more, then speech intelligibility will be somewhat less than optimum, and orchestra music will be a little too dead; but these differences are far less important than having the reverberation time somewhat within the right range initially.

The simplest form of the reverberation equation is $T = \frac{V}{20a}$ in which V is the volume of room in cubic feet and a is the total number of *units of absorption* in the room. More refined formulas are used for specialized studies but are not essential for the present discussion. The number of sound absorbing units is equal to the sum of the absorbing units provided by all of the various surfaces and furnishings within the room. The unit of absorption used here is called the *sabin* (after W. C. Sabine, the originator of modern architectural acoustics). One *sabin* of absorption is the amount of sound absorption provided by one square foot of surface which is perfectly absorbing. Consider an open window beyond which is free space,

[11] Often one specifies the series of frequencies: 128, 256, 512, 1,024, 2,048, and 4,096 cycles per second; this series represents octave intervals starting one octave below middle C. For practical purposes, one can round off these numbers and neglect such differences as that between 500 and 512 cycles per second.

having an area of, say, ten square feet. This open window would then provide ten *sabins* (or ten units) of absorption.

All materials absorb at least a small amount of sound, and no materials are, strictly speaking, one hundred per cent absorptive. It thus becomes necessary to describe the acoustic properties of a material in terms of its *absorptive coefficient*; the fraction of incident sound energy which is absorbed. This coefficient for a given material is independent (except for special cases) of the size of the surface and of its location in the room. Thus 500 square feet of an acoustical material with a sound absorption coefficient $a = .50$ possesses 250 sabins of absorption; and 1,000 square feet of the same material has 500 sabins. Materials which are specifically designed and designated as "acoustic materials" generally have coefficients greater than twenty-five per cent, and frequently greater than seventy-five per cent, over the frequency range in which they are considered useful.

The absorption coefficient of materials generally varies with frequency. For example, a typical acoustic tile may absorb less than twenty-five per cent below 250 cycles per second but more than seventy-five per cent between 500 and 2,000 cycles per second.

Sound absorption coefficients of many commercial materials are listed in the bulletins of the Acoustical Materials Association.[12] Additional information on absorption coefficients can be obtained from many manufacturers, from the National Bureau of Standards, and from textbooks on acoustics.

The relation between reverberation time and the number of absorptive units required (as expressed in the reverberation equation) is indicated in Illustration 37 by the series of curves which are so marked. Clearly, it is necessary to introduce more units into a large room than into a small one in order to achieve a given value of reverberation time.

Illustration 37, therefore, presents the basic information necessary for a satisfactory first approximation of reverberation control. As an example, consider a room of 10,000 cubic feet in which solo singing is the most important function. From Illustration 37 we see that a reverberation time should be about 0.8 seconds for this case, and that 600 sabins of absorption will be required in the room.

The above discussion on reverberation analysis applies to the frequency of 500 cycles per second. Beyond this, however, one should consider other frequencies as indicated above. Here again the optimum characteristic depends upon the use of the room and to some extent on the musical taste of the listener, but considerable leeway can be tolerated. A reasonable guide is the following: the reverberation time at 125 cycles per second should not be lower, nor more than twenty-five per cent higher than the value at 500. The reverberation time at 4,000 cycles per second should lie within 10 per cent of the 500 cycle value for optimum high frequency balance.

[12] Official Bulletin of the Acoustical Materials Association, 205 West Monroe St., Chicago 6, Illinois.

Sound Absorption Coefficients of Common Building Materials, Seats and Audiences

SUBSTANCES	Frequency	Absorption	Coefficient
	128	512	2048
Brick wall, painting	.012	.017	.023
Same, unpainted	.024	.03	.049
Carpet, unlined	.09	.20	.27
Same, felt lined	.11	.37	.27
Fabrics, hung straight:			
Light, 10 ozs. per sq. yd.	.04	.11	.30
Medium, 14 ozs. per sq. yd.	.06	.13	.40
Heavy, draped, 18 ozs. per sq. yd.	.10	.50	.82
Floors:			
Concrete or Terrazzo	.01	.015	.02
Wood	.05	.03	.03
Linoleum, asphalt, rubber or cork tile or concrete		.03-.08	
Glass	.035	.027	.02
Marble or Glazed Tile	.01	.01	.015
Openings:			
Stage, depending on furnishings		.25-.75[1]	
Deep balcony, upholstered seats		.50-1.00	
Grills, ventilating		.15-.50	
Plaster, gypsum or lime, smooth finish on tile or brick	.13	.025	.04
Wood Panelling*	.08	.06	.054
Audience, seated, units per person, depending on character of seats, etc.†	1.0	3.0	3.5
Chairs, metal or wood	.15	.17	.20
Pew cushions (per person they seat)‡	.75	1.45	1.4
Theatre and Auditorium Chairs:			
Wood veneer seat and back		.25	
Upholstered in leatherette		1.6	
Heavily upholstered in plush or mohair		2.6-3.0	
Wood Pews		.40	

* This refers to conventional panelling, ½ to 1 inch thick; special plywood panelling, 1/16 to ⅛ inch thick, randomly braced with 1½ to 3 inch air space behind can give .30 at 128, .20 at 512, .10 at 2048.

† Minimums given. Ranges, respectively: 1.0—2.0; 3.0—4.3; 3.5—6.0.

‡ Minimums given. Ranges, respectively: .75—1.1; 1.45—1.90; 1.4—1.7.

Illustration 43

There are two important precautions regarding reverberation-frequency characteristics. First, one must be careful to select acoustical materials which have adequate absorption below 500 cycles per second, otherwise the reverberation time at 125 and 250 cycles per second will be excessive even if the value at 500 is optimum. The second precaution applies particularly to very large rooms where the absorption of sound in the air itself becomes a major factor. In a room of 250,000 cubic feet, for example, the reverberation time at 8,000 cycles per second would be less than the optimum value for any conditions of use, even if all of the surfaces were perfectly reflecting and if there were no absorptive furnishings in the room. Under these conditions, the best one can do is to provide materials and furnishings which have as little ab-

sorption as possible at extremely high frequencies. Fortunately, it is possible to obtain materials which have high absorption at lower frequencies but have decreasing absorption as the frequency rises above a few thousand cycles per second. This will be the case for a suitably designed perforated facing (metal or asbestos cement board) backed with a sound absorbing blanket, or with specially designed thin panels of wood.

Once the required amount of absorption at different frequencies has been determined, one is in a position to decide what acoustic materials are needed. Since all materials, finishes, furnishings, and even occupants absorb some sound, the contribution from these should be computed first. Under all normal conditions, these "basic units" will fall somewhat short of the total number needed to satisfy the above criteria. The difference between the two is the number of additional units to be supplied by acoustic treatment.

It is always advisable to use materials whose absorption coefficients are guaranteed by the supplier. In addition to the acoustic properties of these materials, there are several practical considerations which should be investigated such as fire resistance, application of paint and its effect on the acoustic properties, strength, and, of course, appearance. The selection of acoustic materials warrants a great deal of care, time, and consideration.

The placement of the absorbent materials is also important. It is generally preferable to place in localized patches or strips, since this aids in diffusing the sound and enhances the sound absorptive value of the material, particularly for low frequencies. It is also useful, especially in larger rooms, to keep certain areas hard and sound reflecting to improve the distribution of sound throughout the room.

Let us conclude the discussion of reverberation control by considering a specific example. To do this we refer to Illustration 43 which gives information on absorptive properties of some common building materials, finishes, and furnishings. Let us assume that we are given an auditorium which is to be optimum for orchestral performance and is to have a volume of 36,000 cubic feet. The dimensions could be 40 feet wide and 60 feet long and 15 feet high. This shape is not necessarily a good one acoustically, but we shall ignore all considerations of sound distribution for the moment and analyze only the reverberation requirements. This auditorium is to have 225 seats, and we shall select heavy upholstery to provide about the same amount of absorption when the seats are unoccupied as when people are sitting in the seats, in order to obtain a reverberation time more or less independent of the number of people occupying the auditorium. Using Illustration 43, we determine the basic absorption units:

Determining Absorption Units

	Sq. ft.		*Abs. Coef.*	*Units of Absorption*
Ceiling, plaster	2400	×	0.03	72
Floor, concrete	2400	×	0.015	36
Walls, plywood panels	3000	×	0.06	180
Upholstered seats	225	×	3.0	675
			Total basic units	963

Let us analyze this problem at only 512 cycles per second. Referring to Illustration 36, a room of 36,000 cubic feet would be optimum for orchestral music with a reverberation time of 1.2 seconds, and from Illustration 37 we see that the room requires about 1,500 units of absorption. The acoustic treatment must therefore provide 1,500 units—963 units + 537 units. Actually a variation of five or ten per cent is not critical; and, indeed, there is this much uncertainty in many of the absorption coefficient values which are available today.

The next logical step is to determine whether some of the required 500 to 600 absorptive units can be obtained by furnishings that are also useful in other ways. In the present example, we might cover the aisles with a felt-lined carpet. If we cover three five-foot aisles running the entire length of sixty feet, we would have 900 square feet at 0.37 units which gives 336 units. We now need about 200 to 300 more units. If the room has a well-shaped ceiling, the remaining absorptive units might be obtained from several panels of comn. cial acoustic material properly distributed on the walls.

Room Shaping—Distribution Control

The shape of a room is of major importance in achieving good hearing conditions, but it has little bearing on the problem of acoustic environment under normal conditions. Basically, the shape of a wall determines the *directions* in which a sound wave will be reflected from it; whereas, the absorption coefficient of the wall determines what *fraction* of the sound energy will be reflected. Actually, the absorptive property may also influence directionality, but to an unimportant extent for the present discussion.

Illustration 44

NON-PARALLELISM CONSTRUCTION
Auditorium Back Wall of the University of Colorado

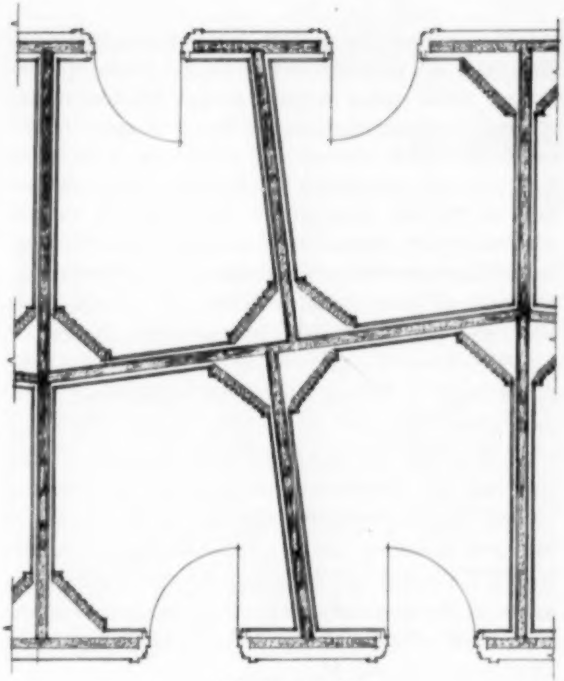


Illustration 45

NON-PARALLEL WALLS AND CORNER SOUND ABSORBERS

Eliminating Flutter, Echoes, and Improving Diffusion

The gross effect of all the sound reflections from all the walls is observed as a pattern of sound distribution within the room. As pointed out in an earlier section, this distribution must have a "proper" character if hearing conditions are to be good; and this means that the sound must be (more or less) uniformly spread over all hearing positions, without disturbing echoes, flutters, or concentrations. We must then find out how this desired acoustic uniformity can be achieved. The relevant problems can be divided into two classes: problems characteristic of small rooms, and problems characteristic of large rooms. The border between small and large may lie between 10,000 and 30,000 cubic feet volume, depending on the design of the room.

In the large room, one must first guard against echoes. These are caused by sounds from a particular source traveling over two different paths which differ in length by more than 65 feet before they reach the listener, resulting in two sounds being heard instead of one. A hard, flat rear wall 40 feet from the stage will send an echo back to a speaker on the stage unless the wall is so shaped that it directs the sound elsewhere. This can be done by breaking up the wall with vertical or horizontal splays or curves. Covering the wall with highly absorptive material will also help but will not usually completely cure echo trouble. A smooth, concave rear wall, with its center of curvature somewhere in or near the auditorium area, will return an accentuated echo that is almost beyond controlling by simple application of absorptive material. Smooth concave surfaces are also dangerous in that they focus the sound, thus sending too much in certain directions and robbing others.

Large rooms also require reinforcement of sound by properly directed reflecting surfaces. Without any such reinforcement, the sound at remote parts of the room will be very much weaker than that near the source (as it is outdoors). Ideally, reinforcing reflections should gradually increase in density toward the rear of the room in about the same proportion as the direct sound decreases. Reflecting surfaces near the source are particularly effective. A stage shell with sloping sides and top will conserve and direct sound from a speaker who might not otherwise be well heard throughout the room if he were standing under an open, high stage. A large part of the side walls and ceilings can also be used for useful reflections if proper attention is given to their design.

In the small room there is no problem of discrete echoes since distances are not great enough. Neither is reinforcement a problem since all listeners are relatively close to the performer and the sound is confined within a small volume. These comments are, of course, based on the assumption that the room is properly designed for noise exclusion and reverberation control. But the small room has its charac-

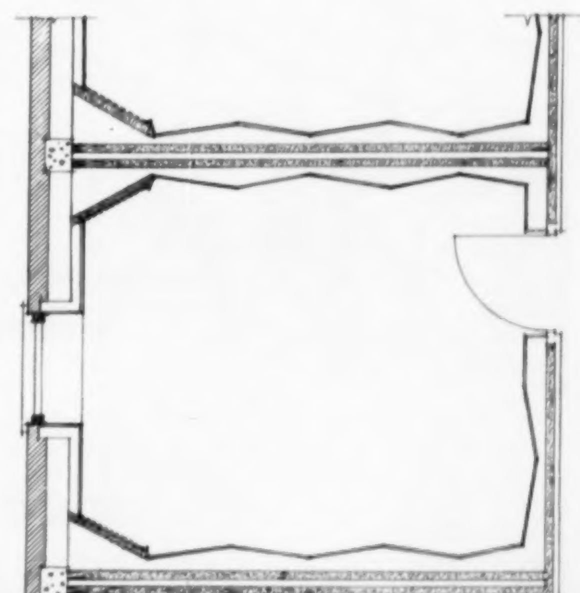


Illustration 46

MODERATE WALL SPLAYING

Eliminating Flutter, Echoes, and Improving Diffusion

teristic difficulties, which are associated with flutter echoes and standing waves.

A flutter echo is a multiple reflection of sound, back and forth between hard, parallel surfaces opposite each other. This causes a disagreeable buzzing sound after each sharp note or speech consonant. Flutter is cured by making walls non-parallel or by breaking up the wall surfaces with splays, convex curved surfaces, or other irregularities of proper size.

Strong standing waves occur in small rooms with low frequency sounds. Then the sound level may differ by large amounts from point to point around the room. Fluctuations of 20 or more decibels are not uncommon; and this occurs even if the source is emitting steady sound. The cure for standing wave trouble is sound diffusion. This is achieved by breaking up the wall surfaces in a random way, with irregularities ranging from a fraction of a foot to several feet in size. This shaping does not really eliminate the standing waves, but it so mixes them and alters their distribution that the sound as a whole—which excites many standing waves at once—becomes more uniformly spread.

It is apparent that both flutter and standing wave difficulties can be controlled by similar kinds of room design. Some rather extreme, though not always unpleasant, wall modulations are found in many of the newer broadcast studios. Of course, good acoustics is of primary importance in radio and recording studios, so it is not surprising to find there the earliest expressions of new developments in acoustic control. Music schools are also coming to realize the importance of good hearing conditions for class, recital, and practice rooms. In one recent design, all practice rooms are trapezoidal in plan, with slants of one foot in fifteen, instead of rectangular. This completely frees the room from flutter and somewhat improves diffusion. Moderate amounts of wall splaying are introduced into most of the teaching rooms. Sound absorptive material is introduced in localized patches or strips; this aids further in diffusing the sound and enhances the sound absorptive value of the material, particularly for low frequencies. Some of these design features are indicated in Illustrations 45 and 46.

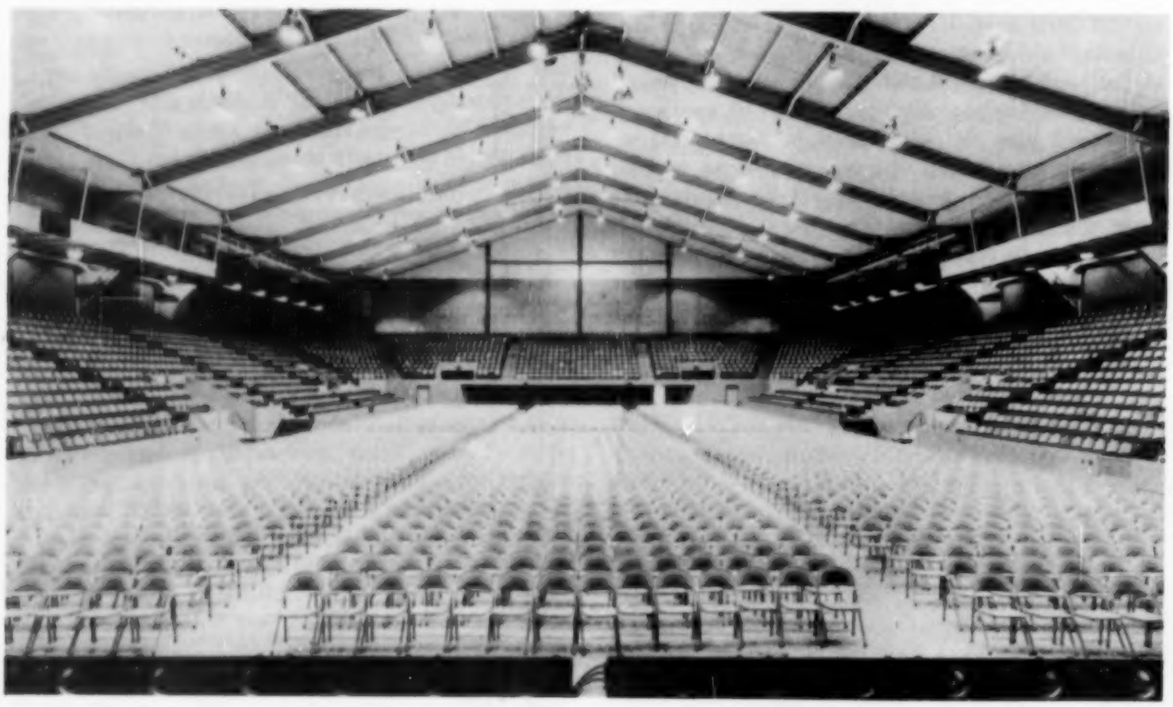


Illustration 47

CANTON, OHIO, MEMORIAL AUDITORIUM

A "restrained" acoustical installation. Portion of the ceiling left open, fiberglass form board on ceiling; white wool and perforated tile on rear wall. Bolt, Bevanek & Newman, Cambridge, Mass., Acoustic Consultants.

VIII

Illumination and Color

Illumination

LIGHTING to enhance the music room environment and to promote student visual *efficiency* and *comfort* involves the application of standard school lighting principles to the specific problems of vocal and instrumental areas. Satisfactory lighting cannot be realized without awareness of typical music room visual problems. Lighting specifications for rooms should consider the following:

(1) Visibility of music is seldom better than typewritten material; it is usually poorer. Small details are important. Non-uniform manuscript, wide range of inks and paper reflectances, size of music symbols, and lack of music printing standardization are current difficulties.

(2) Distance of eyes to the printed page is influenced by the instrument played; and sharing of music often results in awkward positioning of the music. Seeing comfort and efficiency is sometimes sacrificed for overall audience appeal in adjusting music racks.

(3) Musicians are expected to *read rapidly* while also following the director's motions.

(4) Irregular seating arrangements with students facing the director from various angles complicates the problems of eliminating glare and distracting objects.

(5) Music rooms are equipped with furnishings which can create a condition of "visual clutter." Instrumental equipment such as horns, music racks, and folios are in this category and must be considered in the lighting plan.

(6) Charts, diagrams, and details which each member of a large organization must see during rehearsal involves a most difficult seeing task. These materials are usually displayed on a vertical surface where the light level is typically below that of the horizontal plane unless supplementary light is planned. The charts are often viewed from long range and at wide angles.

(7) Music rooms are used day and night, winter and summer, for rehearsals, recitals, meetings, lectures, picture projection, and varied activities with many lighting requirements.

(8) There is a natural tendency for many students to perform by ear rather than sight; good lighting encourages reading the printed page, which is a major music objective.

(9) Posture which promotes the best musicianship is affected favorably by good lighting.

(10) Music classes are especially responsive to an appropriately planned environment.

(11) Rooms with risers must consider that the man *standing* on the *top* rise is in a much different seeing situation in relation to the light sources than the man sitting at floor level or standing on the director's podium.

Comfortable Lighting

The quality and quantity of light in a comfortable classroom are dependent upon three factors:

(1) Illumination level of the task.
(2) Reflectance pattern of the room.
(3) Brightness control of the light sources.

Illumination levels of school tasks has been the subject of extensive research including music reading. The American Standard Practice for School Lighting recommends *30* footcandles as a minimum to be maintained in *general classrooms; 50* footcandles is recommended for *sewing, drafting,* and *typing* rooms. These are feasible minimum standards under present conditions and not necessarily established ideal levels. Music room activities indicate levels *above* that of the ordinary classroom and more in the order of the drafting and typing rooms.

The reflectance pattern of the room influences lighting quantity and quality. Proper choice of colors and finishes within the reflectance range of the accompanying illustration will produce an efficient, comfortable, balanced-brightness environment. The ceiling should be a flat, non-glossy finish. Acoustical materials vary widely as to reflectance value because of the holes or voids in the material; 60-75 per cent may be expected. Indirect lighting efficiency increases measurably with higher ceiling reflectance. Wall areas below the seated students' eye level should be finished for washability and to minimize scuff marks. This can be accomplished by proper choice of materials rather than by using traditional dark paints. Reflectance values of paints are available from many manufacturers.

Music rack surfaces facing the student often form the visually adjacent area to the music being read and should be limited to a brightness ratio with the music of 1 to ⅓. This indicates light, non-glaring finishes on the music rack face. Music folios in light neutral colors would meet the limits of this 1 to ⅓ brightness ratio, and would provide a reading condition comparable to the light work surfaces of modern desktops. The front side of the music stand is often in the field of vision of another player and should be finished to blend with the surroundings. Consideration of the appearance of the stands and folios to the audience when the group appears in concert should also be considered. Furnishings for music rooms finished to meet the recommended reflectance range are available. Trim and floor materials are also available within the recommended reflectance range. The floor is also in the field of view of the student and should not be too dark. Green chalkboards have shown a popularity and growth parallel to the light finished desk; they are easily held in line with the ⅓ brightness ratio of the board with its wall background. Boards with higher than 20 per cent reflectance reduce the contrast of chalk with the board, and visibility of chalk marks accordingly suffers. (Steel chalkboards with fired abrasive enamel surfaces enable small magnets to be used to post bulletins and demonstrate band formations.)

Illuminating engineers are not too concerned with the exact color used on classroom walls so long as it is within the recommended reflectance range.

Illustration 48

RECOMMENDED REFLECTANCE PATTERN

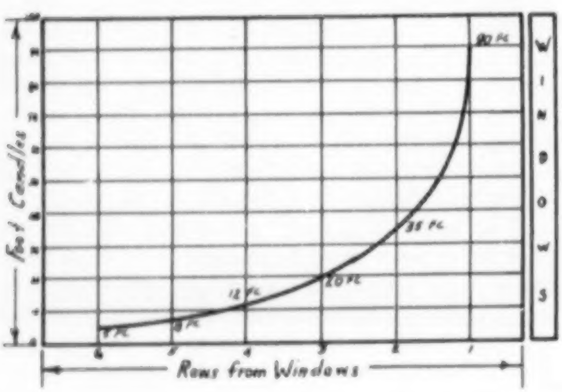


Illustration 49

NATURAL UNILATERAL DAYLIGHT DISTRIBUTION

Gray shades would meet specifications, but the rooms would not be popular—people like color. Color recommendations are generally based upon psychological effect of the various colors. For example, the blue and green which we associate with the sky, lakes and trees are considered to be cool colors. They are frequently recommended for west and south exposure rooms which may feel overly warm due to sunshine. On the other hand, the creams, corals, peaches, and tans are warm colors. They are frequently recommended for north and east exposure classrooms. The cool, light pastel colors are receding colors and tend to make a room seem larger. The reverse is generally true of the warm colors. Greens, especially blue-greens, are quiet colors and people seldom object to them, hence they have wide use.

Brightness control of the light sources involves the shielding and brightness control features of the windows and lighting equipment. Unilateral lighting as

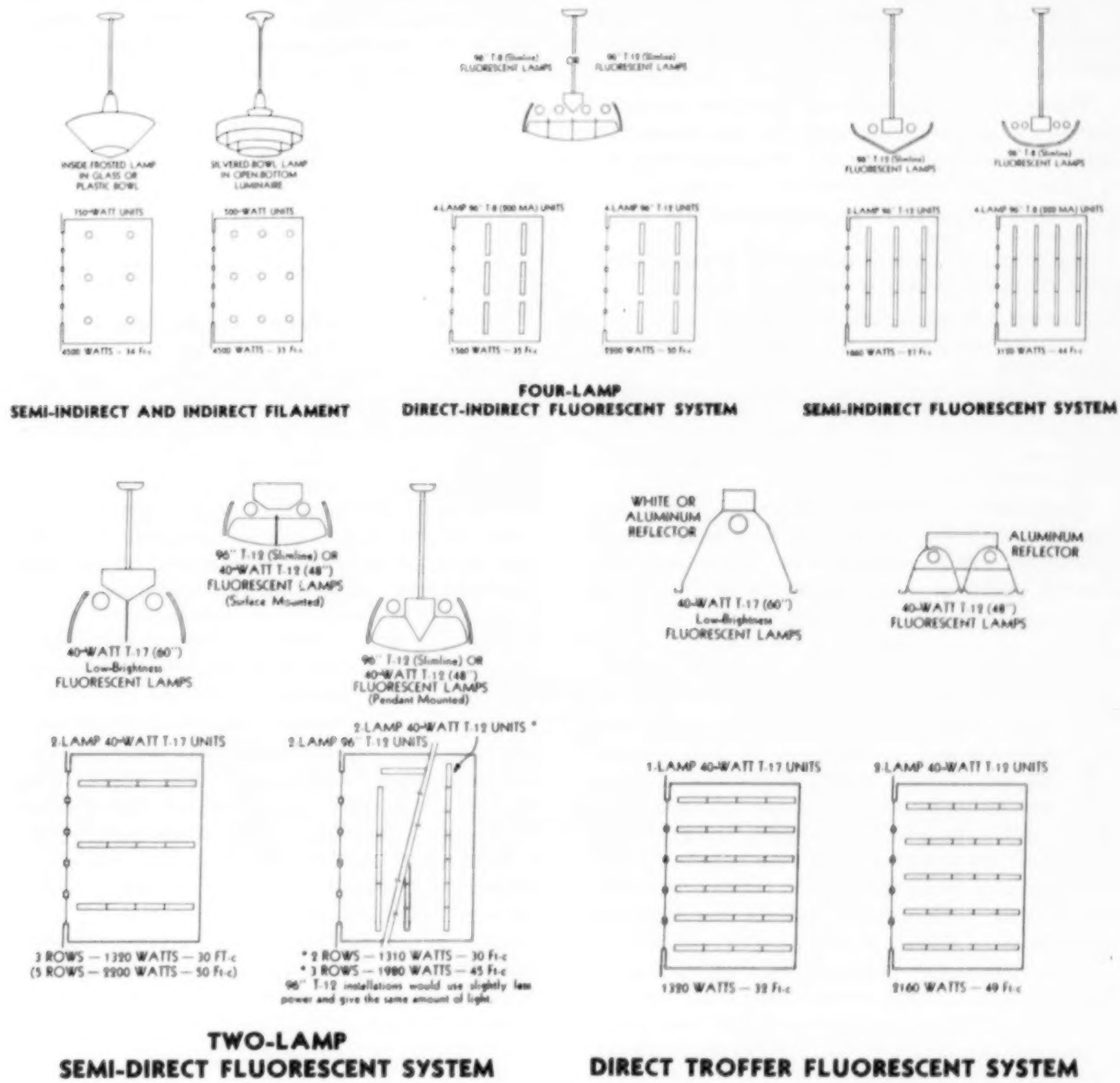


Illustration 50

LIGHTING FIXTURES

provided from windows at one side of the room is included in many room plans. While popular and practical, it does involve inherent problems such as:

(1) Natural light is not dependable (cloudy days).

(2) Evenings and nights, sunlight is not available.

(3) Students near the windows may have very high levels of light (100 footcandles or more), with levels falling off rapidly to the inside rows where you may find less than 5 footcandles on a bright day.

(4) Windows which serve some students well as a light source often are a source of glare and discomfort to the director or others in the room.

(5) At night windows usually become dark areas to those within the room. (Proper shades are usually the answer to the last two considerations.)

Bi-lateral lighting, which is lighting from windows on two sides of the room, helps to prevent the extreme diversity in light levels found in unilateral situations. The direction from which natural light comes is worthy of consideration. Often there is no choice in the direction from which rooms receive the light. East and west exposures afford the best natural light. Typically, southern exposures get too much light, and northern ones do not get enough. Windows are certainly important light sources, and also serve the valuable purpose of preventing a closed-in feeling to those within the room. Weather conditions, architectural design, orientation, fenestra-

tion, wall and ceiling colors, window shades, position of trees and things outside, and types of building materials are all considerations in the natural light planning.

Electrical lighting must be provided in music rooms. A comparison of filament and fluorescent lighting is frequently involved. Fluorescent lighting is indicated where:

(1) Energy rates are average or above, and annual hours of use are long.

(2) The most light is wanted for a given wiring capacity.

(3) Thirty-five footcandles or more are required.

Filament lighting is indicated where:

(1) Energy rates are low and annual hours of use are relatively few.

(2) Footcandle levels are of the order of thirty-five or lower. Higher levels with filament lamps may result in objectionable heat from the high wattage required.

(3) Low initial cost and simplicity of maintenance are prime considerations.

Fluorescent luminaires should provide a minimum shielding of 25 degrees when the fixtures are viewed lengthwise, and 35 degrees when viewed crosswise. Greater shielding up to 45 degrees or translucent enclosure of the lower half of the fixture provide still better brightness control and comfort. The brightness of the shielding elements of the fixture should not exceed 450 footlamberts. (The shielding angle described is that angle between the horizontal and the line of sight at which the lamp is just visible.)

The layouts shown illustrate footcandle levels which might be expected in an average 22′ x 30′ classroom, finished as recommended, and using typical luminaires. Proportionately more lamps and equipment would be required to obtain equal levels in larger rooms.

The selection of luminaires and planning of the installation should be done with a competent illuminating engineer. School architects, building consultants, power and light companies, and lamp manufacturers are sources of this service. These specialists can balance initial cost, energy rates, hours of operation, and maintenance considerations to arrive at an overall cost figure, and their knowledge of lighting equipment, its installation, and the resultant effect will help to assure satisfactory illumination of the music room and its adjacent specialized work areas.

Color

Young America, now climbing the steps of learning, enjoys many benefits in improved teaching methods and modern equipment for protecting health and making of him a more efficient student with a greater potential for success. He is, in fact, the plastic material of the nation's future. In moulding him, the modern educator holds the destiny of America in his hands.

It is a well-know fact that color affects and influences human beings of all ages. Scientific tests have shown that some colors stimulate and excite. Others smoothe and relax. Still others create fatigue, depression, and irritation.[13]

More and more, educators and school authorities all over the country have become aware of the important part color plays as an aid in creating an atmosphere that promotes efficiency and morale among pupils and teachers alike.

When you select colors for schoolrooms which merely seem to be attractive, you may be forcing those who occupy these rooms to work and study in surroundings that are psychologically unsuited to them. Such surroundings may gradually get on their nerves, affect their work, cause them distress and unhappiness.

Eliminate these adverse conditions and you not only stimulate energy and improve concentration—but you likewise raise morale. You help to bring about a better spirit among teachers and students. You improve their spirit of cooperation and loyalty.

The correct use of color, combined with proper maintenance, gives teachers and students a feeling of pride in their surroundings and fosters a desire to assist in keeping them neat and orderly. Selection and placement of colors should be in keeping with their function, exposure to sunlight, and available lighting facilities.

Warm and Cool Colors

The rules governing the use of warm and cool colors hold good for use in school decoration. The power of warm colors to counteract the effect of cool light from north or east makes them the logical choice of rooms having those exposures, or those receiving little light due to shade from nearby buildings or other obstructions.

The warm colors are those in the range of yellow, orange and red. They are known as warm colors because they suggest heat, blood, and sunshine. Their use is governed by their psychological effect which is one of stimulating warmth and cheer.

On the other hand, the cool colors are used to best advantage in tempering the strong, warm light from south or west.

The cool colors are those containing blue. They suggest the hues of winter, ice, snow, and expanses

[13] This section on Color is a reprint of portions of a pamphlet called *Pittsburgh Color Dynamics for Grade Schools, High Schools, Colleges*. We are grateful to the Pittsburgh Plate Glass Company of Pittsburgh, Pennsylvania for their permission to use this material.

of water. As with the warm colors their use is determined by the effect they produce, i.e., a feeling of coolness, calmness, and restraint.

Determining the Value of Colors to be Used

Color value, that is light or dark color, is important in two ways for schoolroom decoration.

The first rule is rather obvious—that the lighter values should be used in rooms which tend to be dark, thus securing the maximum of reflected light. Lighter rooms may have darker walls, and in the case of rooms receiving strong glaring light, the colors of medium or darker value reduce the strength of the reflected light.

Color values have additional powers, such as changing the apparent proportions of rooms. They may also be the means of equalizing the distribution of reflected daylight in a room. Both of these functions are dependent on the selection of the right color values and involve the additional problem of their correct placement in the room.

The Placement of Colors

It is desirable to secure variety throughout the school being decorated by the choice and placement of colors. The avoidance of monotony is vital and the use of more than one wall color is often advocated. Some areas call for stimulating colors while calm, soothing colors are more appropriate in other places.

In classrooms devoted to certain subjects it is highly important to secure and retain the attention of the pupils where the instruction is being given. One can meet this problem with a functional application known as focal wall. The focal wall is painted a darker or lighter value of the color used on the other three walls, or a contrasting color—one which will focus the attention of the students on that part of the room, and, at the same time, not be conducive to eyestrain. A darker color is most often used for establishing the focal wall, since a slightly darker value is usually more restful than the lighter colors surrounding it. In this case the same color may be repeated on the lower portion of the other three walls, where there is a dado or wainscot.

An important consideration should be the atmosphere in which teachers work. They should never be forced to look into strong light. Wherever possible a wall painted in an eye-rest color should face the teacher. In cases where a focal color is used on the front wall, the same color should be used on the opposite wall for this purpose, provided the teacher faces it often.

The light in some classrooms, coming from only one direction, seems particularly strong and concentrated on the wall opposite the window wall. The reflected light in such a room is often equalized by the use of wall colors in three values. The darkest color is applied to the wall opposite the windows where the light is strongest. The two end walls, which receive slightly less direct light are painted in a lighter value, and the window wall which receives little or no direct light is painted in the lightest value of the three.

As an example of the above method, a room with an almost glaring light from the south might be painted as follows:

Wall opposite windows—green.

End walls—intermix of equal parts green and white.

Window wall—intermix one part darker green and four parts of white.

It is preferable, in the average classroom, to finish the ceiling to reflect the maximum amount of light. This restricts the range to white, soft white, cream, ivory, or a very pale tint of a wall color, or a contrasting tint. Such colors should have reflection factors within the range of 80 per cent to 85 per cent.

In other rooms in the school where the maximum amount of light is not required to be reflected from the ceiling, a more pronounced color is not only effective from a decorative standpoint but may also serve a definite purpose functionally. In a cold north or east room a ceiling in sunny yellow or peach will serve to give a cheerful effect to the entire room. The glare of west or south light in rooms facing those directions may be counteracted effectively by using light green or blue-green on the ceiling.

Light and Dark Values

One can make use of light and dark values of color in changing the apparent proportions of rooms. Sometimes it is desirable to equalize the dimensions of a long, narrow room. In this case, the end walls are painted in a relatively dark color, a lighter value of that color, or a harmonizing hue being used on the long side walls. This placement of light and dark values is based upon the fact that in juxtaposition to each other dark colors seem to advance and light colors to retreat. Thus the length seems diminished and the width increased.

In square or nearly square rooms the lack of interest in proportion is often made less apparent by painting one wall a different hue than the other three. This concentration of interest on one wall makes the fact that all walls are of the same approximate dimensions less noticeable. If the window wall is used for this purpose it should be lighter than the others, and if the opposite wall is used, it will be darker than the other three, in accordance with the rules for equalizing light.

Selecting Colors

The choice of colors for the average classroom depends not so much upon the use of the room for instruction in a particular branch of learning as upon other factors such as exposure, amount of natural and artificial light available, proportion of the rooms,

need for focal wall or three-value walls, and similar considerations. The age of the students should also be considered. The subject being taught might also influence color choice, though many schools, particularly the smaller ones, use classrooms for instruction in more than one subject.

Other rooms in the school building require definite color treatments based upon their uses. A few suggestions:

Auditoriums: An auditorium in a school serves as a lecture hall, concert hall, theater and assembly room. Painting an auditorium is purely a decorative problem, and its decoration depends entirely upon its architecture and the colors of the objects that are present and cannot be changed; for example: the stage curtain, drapes, sets and floor. There are a few general rules that might be well to keep in mind. If the auditorium is small, it is advisable to use cool receding colors for walls and other vertical areas, such as shades of green, blue, and so forth, with the ceiling in a contrasting warm hue, such as rose or yellow. For the larger auditorium warm colors may be employed or a variety of warm and cool colors.

Music Rooms: A music room may be well treated as a room of some stimulation, employing warm and cool colors.

Offices: Offices should be dignified and conservative, making use of the light at hand, both natural and artificial, for the eye comfort of the workers. Where the light is of higher intensity than required, colors having lower light reflection factors should be used. Where the light is adequate or slightly on the low side, the color should have a higher light reflection factor. This is merely balancing color with light. Where direct or semi-indirect lighting is used the ceiling should be finished in white.

Assembly Rooms: Such rooms as these, where the students are gathered together at intervals, should have an atmosphere as different as possible from that of their classroom activities. The background of color should not only be restful and relaxing in feeling, but should put the student in the proper mental attitude to participate wholeheartedly in the activities of the assembly.

Illustration 51

MUSIC ROOM

New Trier Township High School, Winnetka, Illinois

IX

Heating and Air Conditioning

HEATING and air conditioning,[14] as the term implies, refers to the heating of a building and the treatment of air supplied and circulated through a ventilating system to clean the air and control the temperature and humidity within the occupied space both winter and summer. Summer cooling systems, of course, are at present rather expensive for the average school, but are a desirable feature.

In designing the music department of a school, as in any application of heating and air conditioning, the comfort and health of the occupants is a prime consideration. Proper temperatures and humidity levels should be maintained. Various authorities have shown that proper ventilation, uniform temperatures and humidity play an important part in the health, learning and teaching abilities of the occupants of a building.

The design of a heating and air conditioning system is a problem that should be solved by competent design engineers trained in this particular field. The music director, however, should inform the design engineers of the following points peculiar to music education and should check to see that these items have been included in the design insofar as economic considerations permit.

(1) As wind instruments require a great deal of inhalation and exhalation of the player and some instruments require considerable physical exertion to play, a mechanical ventilation system and fresh air supply in excess of normal design should be provided. In fact, in the average school practice room, larger singing or instrumental groups often generate enough heat to make the room uncomfortable even though no heat is added to the room. To avoid this problem of overheating, it is necessary to provide a controlled source of cooler air. This function can often be taken care of very well by the introduction of outside air through a central system or room unit ventilators of proper size.

While natural window ventilation is the cheapest type to provide in most of the nation's schools for most of the school year, it permits noise nuisance to adjacent areas and makes temperature, humidity, and dust control difficult. Gravity ventilation is hard to isolate acoustically and requires much space and ductwork to be effective and approaches the cost of mechanical ventilation with few of its advantages. Window and gravity ventilation alone is advisable only in smaller schools and in the warmer parts of the nation.

(2) Ventilating ducts, which are normally constructed of some form of sheet metal, are excellent sound transmitters. To reduce the transmission of sound from room to room the ducts should be lined with fireproof acoustical material or constructed of specially designed acoustical material (e.g., asbestos) or provided with baffles and then bends, or combinations of these methods in sufficient quantity to provide the desired sound absorption.

(3) The pitch of a musical instrument is affected by temperature change, and the change in pitch per degree temperature change is not the same for all instruments. To maintain the instruments in tune, a consistent and uniform temperature in the music room is highly desirable.

(4) The stringed instruments (this includes pianos) are especially sensitive to changes in humidity and temperature, and suffer damage if the humidity is too high or too low. The recommended relative humidity for practice rooms and instrument storage rooms is 40 to 50 per cent. Provisions for automatically maintaining this level should be included in the design wherever stringed instruments are stored.

(5) For the production of music, quick mental responses are necessary. Thus, it becomes imperative to maintain healthful and comfortable conditions in the music room. The recommended dry bulb temperature range for comfort is from sixty-eight to seventy-two degrees Fahrenheit.

To satisfy the conditions outlined above, the music department of the school should be equipped with a heating and air conditioning system that will provide a constant uniform temperature, supply clean air composed of adequate fresh air and recirculated air, and maintain the proper humidity where instruments are stored and played.

Where conditions warrant and it is economically feasible mechanical cooling should be employed to provide the desired results (see page 26). Usually the introduction of properly controlled outside air will provide satisfactory cooling at a minimum of expense.

The use of automatic temperature and humidity controls can effect considerable savings in fuel and power and should normally be utilized.

The first cost of proper heating, air conditioning equipment, and temperature control is small when compared to the benefits received from a comfortable, invigorating environment for musical education and the savings effected by minimizing deterioration of valuable musical instruments.

[14] This section was prepared by Garni Moretti and Thomas Haw of Snyder & McLean, Engineers, Detroit 26, Michigan.

X

Equipment

It has been demonstrated through usage that certain types of equipment give better service to music departments than similar articles which may or may not be considered satisfactory for other departments of a school. It is the equipment within a building that finally makes that building usable and workable as a school. A music department which is poorly equipped, even though excellently housed, cannot be expected to make progress at the desired rate. All good workmen are judged by the tools with which they work. If adequate, good equipment is supplied to a competent music teacher, success is assured in almost every music department. In far too many schools, definitely able directors are seriously handicapped by the lack of proper equipment. An important maxim in purchasing any school equipment is: *buy something good and then take care of it.* The following recommendations are made for school music department equipment.

Music Stands

It is recommended that schools purchase a high quality non-folding stand which is heavy and durable—a telescopic metal stand with a heavy, non-breakable base. In most cases it is safe to estimate fifty stands for an instrumental group of seventy-five, or a ratio of 1:1½. Extra stands will be needed for the practice rooms. Students often provide their own (folding) music stands for special appearances when school stands are not readily transported.

Chairs

High-quality, non-folding chairs are recommended. Comfort should be given special consideration. The legs should have rubber tips or rounded metal plates to protect the floors. It is desirable to have a shelf under the chairs for books and music. String bass players should have wood or metal stools (approximately thirty inches high, such as are used in many factories). It would be well to purchase a swivel stool (throne) with adjustable height for the timpanist. Cellists should have chairs which will enable them to sit on the forward edge to play the instrument. These chairs should be somewhat higher than ordinary chairs—nineteen inches is the recommended height for most players.

Illustration 52

Conductor's Podium

The podium should be movable and its construction should match the room or stage. The minimum size would be approximately eight inches high and the top should be about three feet square on top. A larger podium (fourteen inches high and three feet square, with a twelve-inch wide step fastened on each end) is more satisfactory for larger instrumental groups. In order to prevent slipping, the top should be covered with rubber sheeting. To avoid scratching the floor, metal gliders should be placed on the corners.

Small Stage

If the rehearsal room is to be used as a small auditorium for music and non-music groups, it is well to have a portable stage available. Minimum size: eight feet by six feet by one foot.

Bulletin Board

The cork board for official notices should be near the music director's office. It should be built right into the wall, so as to be neat as well as secure. This bulletin board should be encased in glass with an inside light and equipped with a door that can be locked. Another board can be reserved for posting general notices, information, advertisements, cartoons, and other less official news. Thirty inches by thirty inches is a good size for the bulletin board.

Chalkboards

Chalkboards should be built in as permanent fixtures on both sides of the conductor's podium in the rehearsal room. They can be used to list the rehearsal routine for the period, emphasize important announcements, and as a general teaching aid. Portable chalkboards have many uses in a music department. One side should be slate and the other side constructed as a cork bulletin board. Light green chalkboards are recommended. Some chalkboards should have staff lines on them. The lines should be approximately an inch apart and three or four inches between the staves. Some manufacturers will line the boards at the factory.

Song Book Cart

Many grade school music teachers have had special boxes fitted with rubber wheels and handles to facilitate carrying songbooks, phonograph records, and other equipment to classrooms.

Sheet Music

The music library is as important to the music department as is the literary library to the school as a whole. The proper care of sheet music, which must be issued in large quantities to music students, requires special equipment and efficient handling to prevent heavy losses.

Sheet music is satisfactorily stored in steel filing cabinets of the four-drawer type or in specially made boxes, while music books are stored on shelves as are other books. The distribution and collection of sheet music is usually accomplished by means of folios in which the music is inserted and from which it is later removed by the music librarian as directed by the instructor. A well-equipped and conveniently located music library, which is large enough to serve as a workshop as well, is an essential unit if the music department is to function efficiently.

Music Folder Cabinet

A good storage cabinet for rehearsal folders is a great convenience and time saver. In order to facilitate prompt starting of band and orchestra rehearsals, the folios of music should be accessible to the students as they enter the rehearsal room. The storage cabinet for the folders should be such that it permits quick visibility and handling.

Two folio cabinet styles are in general use. One is the upright cabinet containing compartments fitted to hold the folders of music in a vertical manner. Each

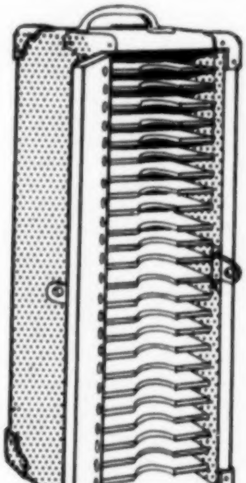


Illustration 53

PORTABLE MARCH FOLDER CABINET

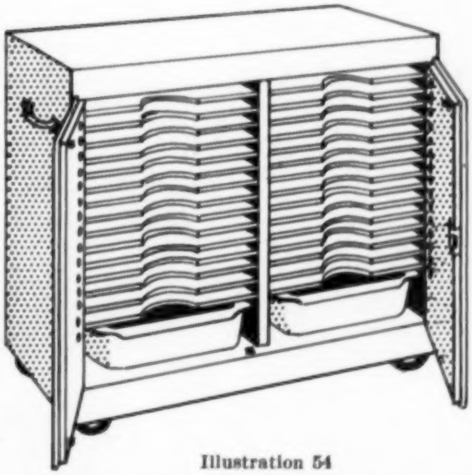


Illustration 54

PORTABLE CONCERT FOLDER CABINET
Dimensions: 30" x 16" x 42" High

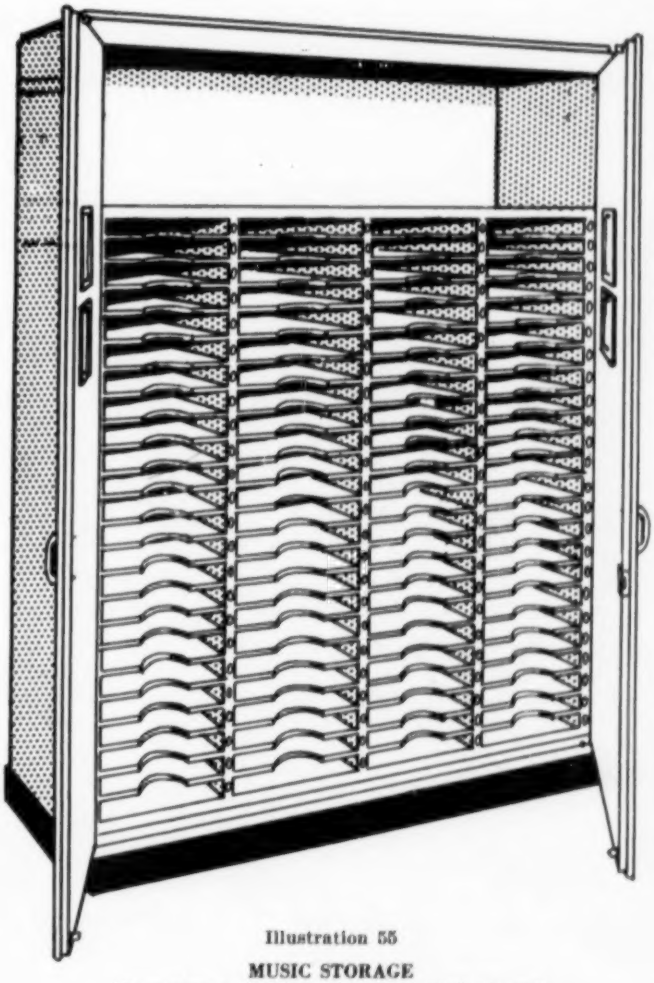


Illustration 55

MUSIC STORAGE
Dimensions: 62½" x 16" x 83" High Overall

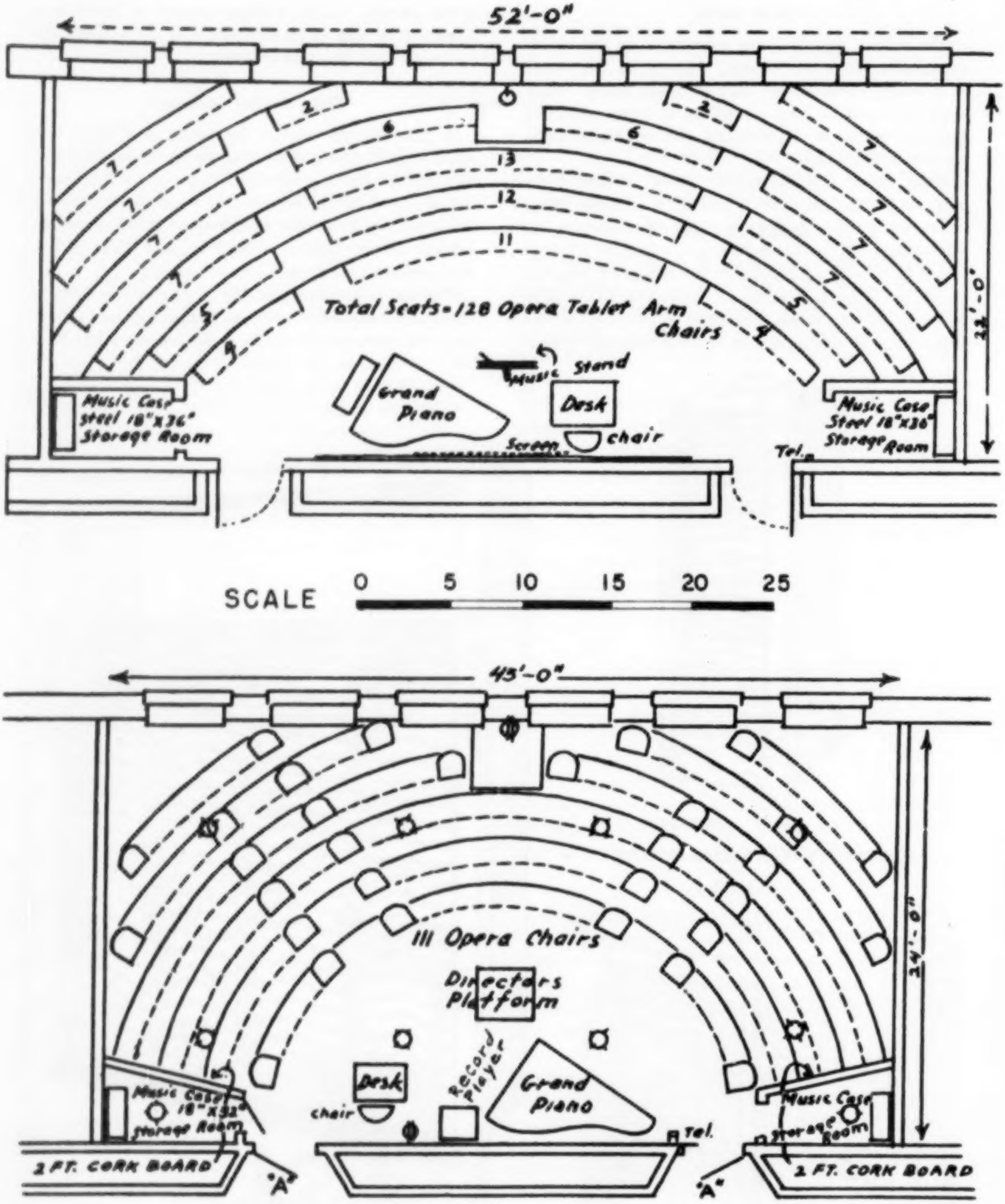


Illustration 56

STANDARD EQUIPMENT—MUSIC ROOMS
Board of Public Instruction, Pittsburgh, Pennsylvania

individual compartment should be large enough to hold concert-size folders of music with sufficient clearance so that the folders will not tear or wear too much as they are removed and replaced. Approximately seventy compartments, each twelve and one-half to fifteen inches by fourteen and one-half or fifteen inches with two inches between partitions, should be provided. One of the compartments should have four or five inches between partitions for the director's music.

The director's full scores require more space than do the regular scores for individual performers. A cabinet with slightly over one-half this number of compartments, but of the same size, is sufficient for smaller instrumental organizations. Some choral directors use this style of cabinet for choral music but have the compartments to fit octavo music. In planning and constructing a vertical folder cabinet, care should be taken to see that the cabinet is not top-heavy because of extreme height. A wider cabinet of less height is better. This style cabinet is also serviceable as a sorting rack.

A second style that is preferred by many directors is the horizontal pigeonhole cabinet containing compartments to accommodate all of the folders. The individual compartments would need to be the same size as the one mentioned for the verticale style cabinet. A cabinet that is approximately thirty inches high, thirty inches wide, and sixteen inches deep will hold two rows of eighteen folders and is sufficient for small bands or orchestras.

These cabinets should have doors fitted with locks. They should be equipped with rubber casters so that they can be easily moved. They should be numbered and individual students assigned folder numbers with corresponding compartment numbers. Partitions in either style cabinet should have small semicircular recesses so that folders may be grasped with ease as they are removed from the compartments.

A style preferred by some directors is built-in shelving in the rehearsal room. These may be either shelves for individual folios, as described in "Music Cabinets", or a shelf for each section of the band, orchestra, or chorus. Twelve to fifteen shelves would be sufficient for each organization. Under this latter plan the head of each section passes and collects the folios at the beginning and end of each rehearsal. Some directors feel that this method is a time saver, and causes less confusion than where each member is responsible for getting his own folio from the cabinet. Cabinets for all the folios of the section probably should be 16 inches wide, 6 inches high, 14 inches deep. This size would take care of either large band or orchestra folios or octavo size folios.

Music and Record Filing Cabinet

A music department library should be supplied with several filing cabinets for vertical filing of music and phonograph records. These cabinets may be purchased in two, three, four, and five-drawer models, but the standard four-drawer model has proved to be the most desirable and serviceable. The letter-size file serves well for filing vocal and most instrumental music. Some compositions, especially foreign editions, are printed on over-size paper and should be stored horizontally; if vertically filed, they should be put in legal-size filing cabinets. Phonograph records fit well into legal-size filing cabinets, but great care should be taken to see that the records are kept securely in a vertical position so as to prevent warping caused by pressure and heat. Filing cabinets equipped with roller or ball bearings are superior to those without these bearings. Files may be of steel or wood. The wood files are better and can be had in colors to match the other furnishings.

Several filing cabinets can be placed together to form a filing unit. This is possible when careful selection has been made to secure files all of the same

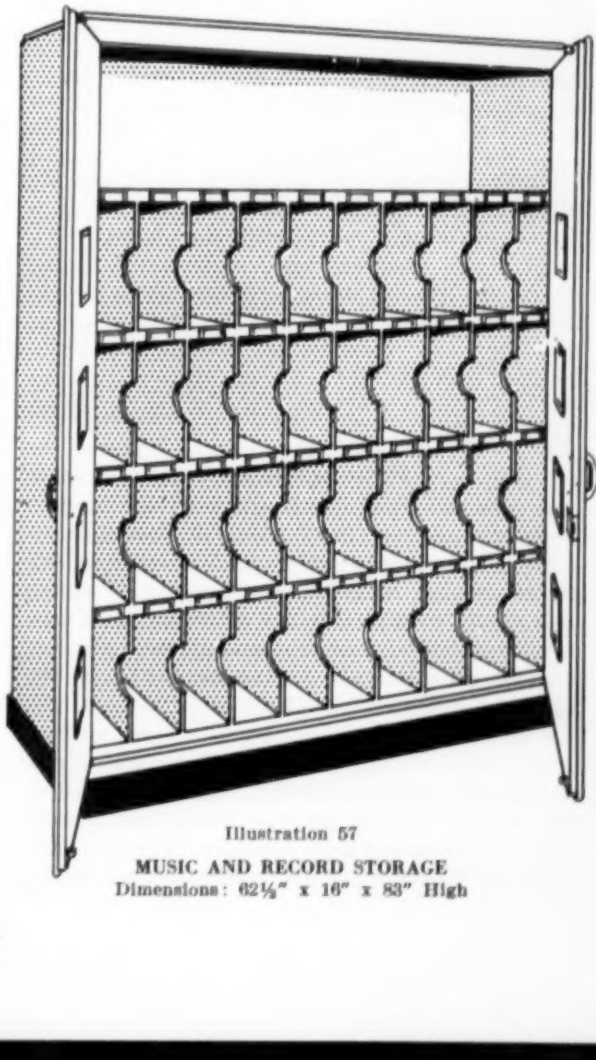


Illustration 57

MUSIC AND RECORD STORAGE
Dimensions: 62½" x 16" x 83" High

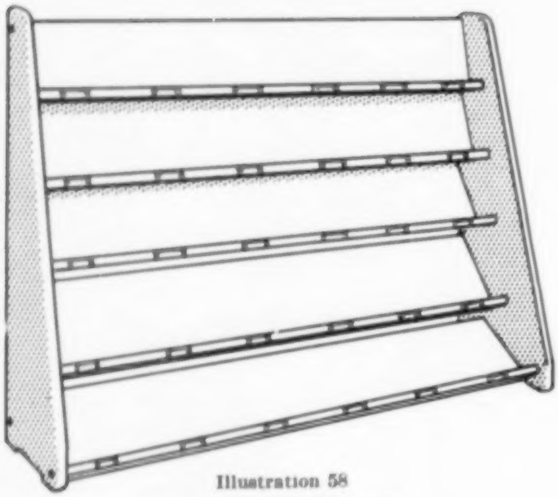


Illustration 58

MUSIC SORTING RACK

Dimensions: 48" x 72" Long; 24" x 74" High

height and depth. In such a unit it is wise to construct shelves or cabinets over the files to make the space useful and also to prevent books, music supplies, instruments, and many other small items from being stacked promiscuously on top of the files. This also makes possible complete anchorage of the files, so that if all of the drawers of a file were pulled out at the same time the file would not tip over.

Storage Cabinets

Storage cabinets made of either wood or steel are excellent for horizontal storage of music as well as for miscellaneous supplies—instruction books, manuscript paper, recording discs, paper supply, music scores, etc. Wooden storage cabinets may be built in a library room or office, with size determined by available space. Steel storage cabinets are sold in standard sizes and may be purchased with adjustable shelving. This type of cabinet is excellent for storing books or any flat object.

Music Sorting Rack

Every music department should be equipped with a music sorting rack. Such a rack is convenient for distributing music to folders and for reassembling the music when ready for storage again. A sorting rack should consist of four or five slanting shelves, one inch by fifteen inches by seventy-five inches (or longer), with one inch by two inch strips at the bottom of each shelf to hold the music in place. The size of the largest folios used in schools is about twelve inches by fifteen inches. Each shelf of the sorting rack should be made to hold a desired number of these folders, allowing two inches between folios for overlapping of music, or fourteen inches width per folio. Two or more racks should be placed against the wall or walls of the music library, rehearsal room, or office, preferably at a corner, so that the person or persons using the racks may do so with a minimum of walking.

Sufficient shelf space should be provided for the greatest number of folios used by any one musical organization. This rack may be used equally well by both vocal and instrumental music organizations.

Instrument Storage Equipment

Whenever possible, instrument lockers, cabinets, and shelves for all instruments should be located conveniently in the rehearsal room or adjacent storage room. The equipment of such storage facilities will be discussed later. Since musical instruments are delicately made and easily damaged, they should not be strewn around the floor of the rehearsal room. Even when the utmost care is exercised in placing them neatly, they still give the room a cluttered appearance. Provision should be made for their safe and efficient storage. There are several effective plans for the storage of such equipment and some of them will be discussed in this section.

Shelves, Lockers, Cabinets

Cabinets of wood may be built or purchased factory-made to be installed around the sides of the room and also the back of the room if windows are

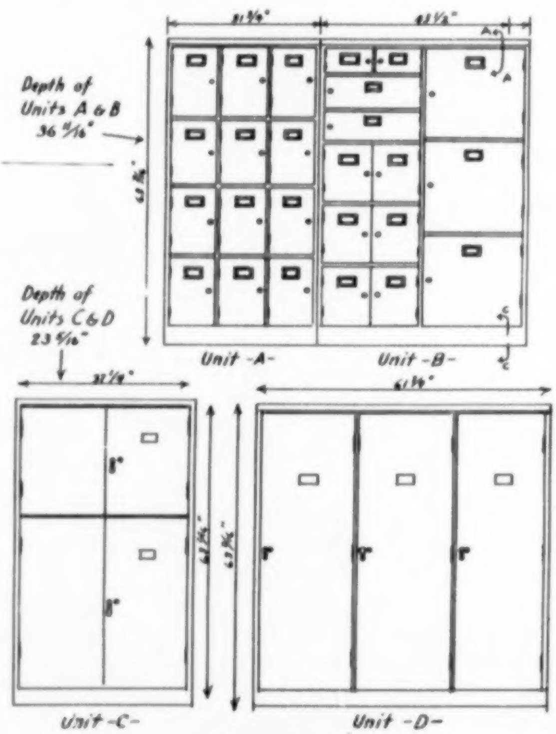


Illustration 59

STANDARD STEEL MUSIC INSTRUMENT STORAGE CASES

Board of Education, Pittsburgh, Pennsylvania

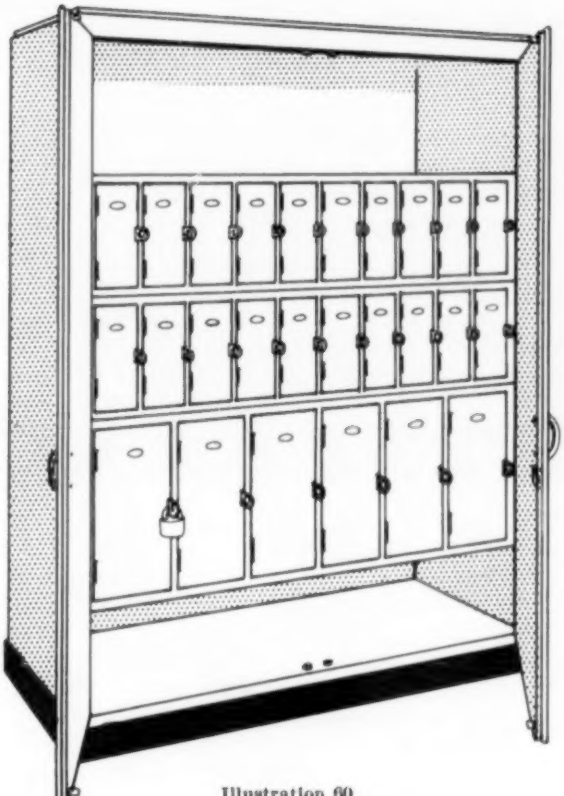


Illustration 60

INSTRUMENT STORAGE

Dimensions: 62½" x 40" x 27" Deep x 83" High

not a problem. The trend for light finishes in classroom woodwork is one reason wooden cabinets are suggested rather than steel. This, of course, is a matter of personal opinion and each school should use what fits its situation best. Space at the front of the room should be used for chalkboard, bulletin board, and charts that aid in the instruction of music. Lockers and cabinets are better than shelves because they may be locked. It is difficult, however, to furnish such cabinet space for all instruments in the average rehearsal room.

A plan, that does not use too much floor space, is to construct individual shelved compartments for clarinets, cornets, trumpets, flutes, oboes, bassoons, alto and bass clarinets, alto saxophones, fluegelhorns, violins, and violas. Shelves should be about fourteen inches deep from front to back with individual compartments from eight to ten inches high. Shelving should start above the mopboard and provide storage to a height of five or six feet. Partitions should be placed so as to make spaces from approximately eighteen inches for smaller instruments, such as cornets, clarinets, oboes, flutes, et cetera, to approximately twenty-six inches for longer instruments like violins and violas. The total number of shelves would be dependent upon the number of instruments for which storage would be necessary. Each individual compartment should be numbered to facilitate the storing of these instruments and to prevent misunderstanding among the students as to the proper place for each instrument.

If such shelving is planned before the building is constructed it is wise to have it recessed in the wall. This plan makes the shelving more secure and prevents dust and dirt from collecting on top of exposed shelving. Instruments other than those named above should be stored in lockers or cabinets built round the room. When such cabinets are constructed, great care should be taken to see that the proper dimensions are planned before construction begins.

Cabinets free from any obstruction at floor level should be provided for timpani, vibraphone, marimba, and xylophone. These cabinets should be large enough so that the instruments can be rolled easily into the cabinets. Double doors should be installed so that the doors will not swing too far into the room. It is advisable to build cabinets for such instruments as snare drums, French horns, trombones, baritones, and tenor, baritone, and bass saxophones, above the cabinets for timpani and the keyed percussion instruments.

For such instruments as violoncellos, bass viols, and sousaphones, the Sherrard Roll-Away Racks may be used. These racks are excellent for the storage and protection of these instruments. Although the racks are patented, they may be purchased from their inventor[15] at reasonable cost. The three styles of racks are furnished with rubber casters, padded with serviceable material to prevent marring of instruments, and are constructed of oak finished wood to fit into any type of rehearsal room.

The violoncellos, bass viols, and sousaphones, can be safely placed on the Roll-Away Racks and can be moved easily around the rehearsal room for convenient placing. Likewise, the racks facilitate moving these large instruments to the auditorium stage for program use. It is a good plan in new building construction to build cabinets with no obstructions at the floor level and with large double doors so that a rack with the instruments placed upon it can be moved into position for safe storage. Overhead, disappearing doors are superior to hanging doors since they do not swing into the rehearsal room and interfere with chair setups, etc. In planning cabinets to hold racks and instruments it is suggested that detailed specifications be examined in order to secure proper dimensions and to see that generous space is allowed for adequate clearance.

[15] Wayne F. Sherrard, Illinois State Normal University, Normal, Illinois.

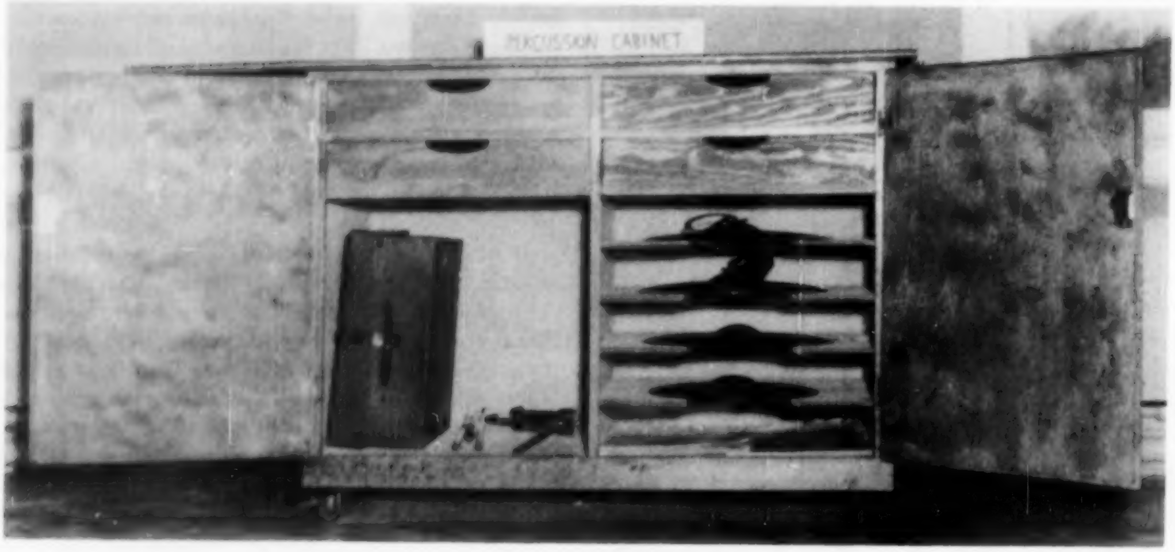


Illustration 61

PERCUSSION CABINET
Plainview High School, Wichita, Kansas

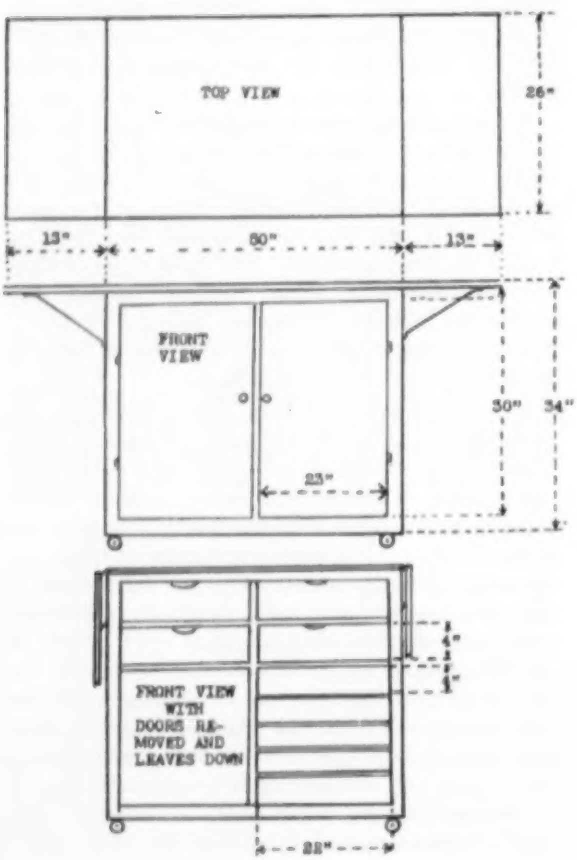


Illustration 62

PLAN FOR PERCUSSION CABINET (Front View)

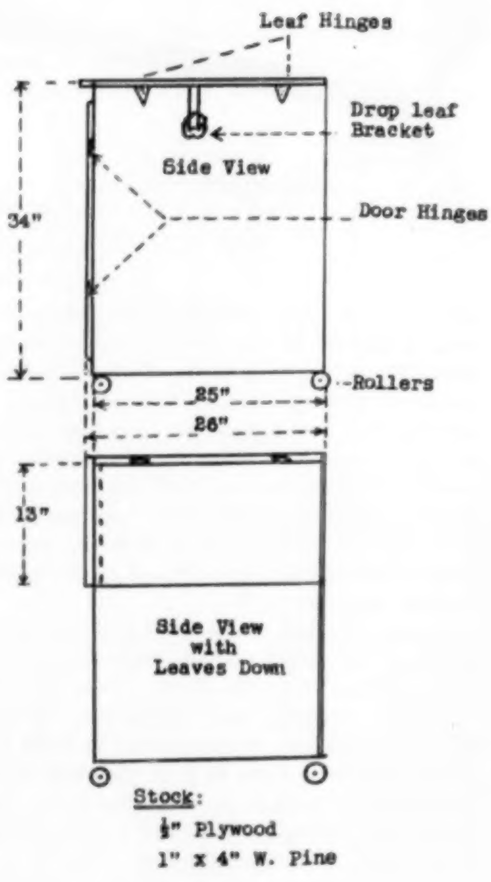
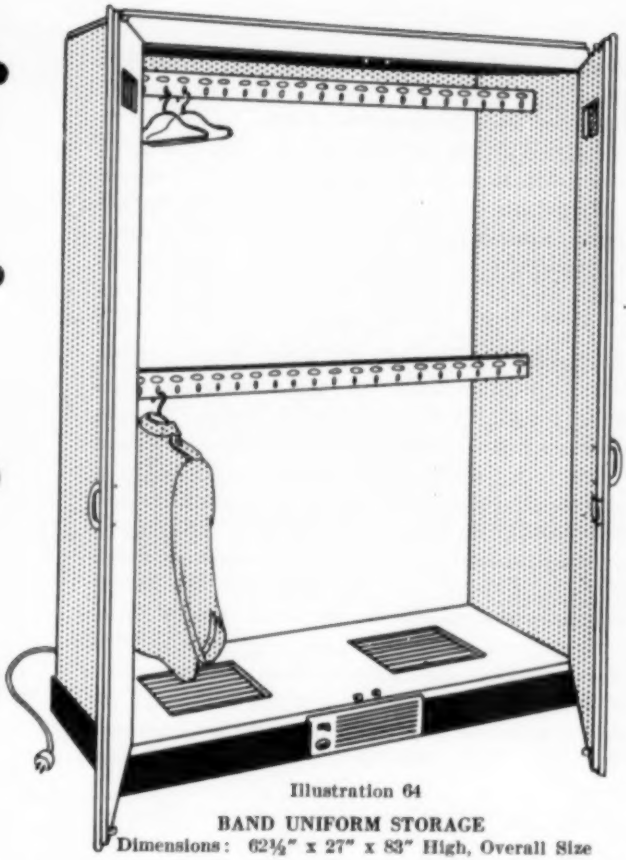


Illustration 63

PLAN FOR PERCUSSION CABINET (Side View)



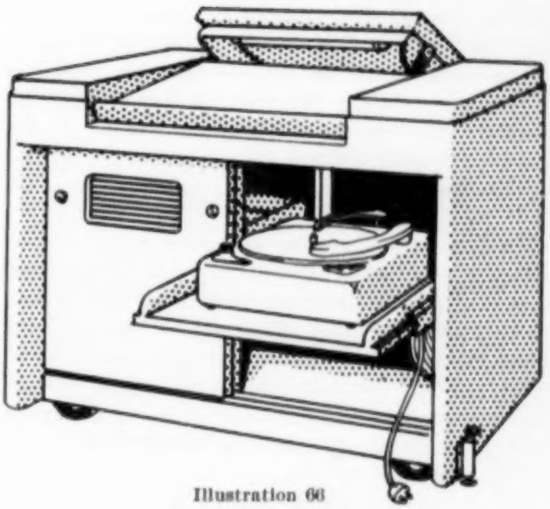


Illustration 66

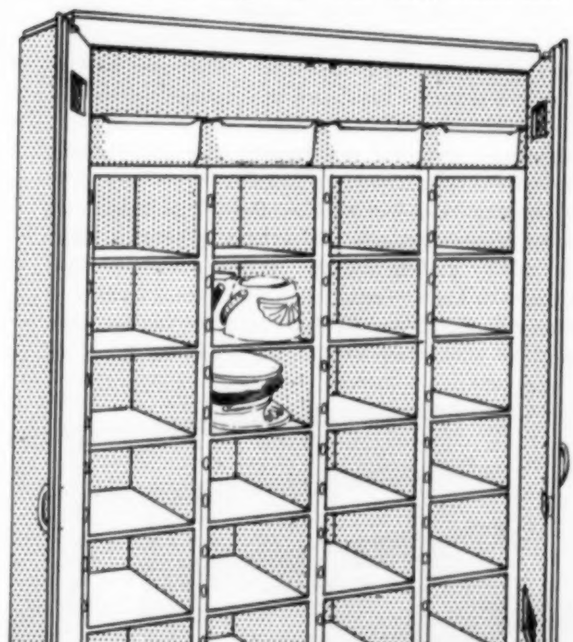
PODIUM CONSOLE

Dimensions: 48" x 28" x 38" High When Closed

Illustration 64

BAND UNIFORM STORAGE

Dimensions: 62½" x 27" x 83" High, Overall Size



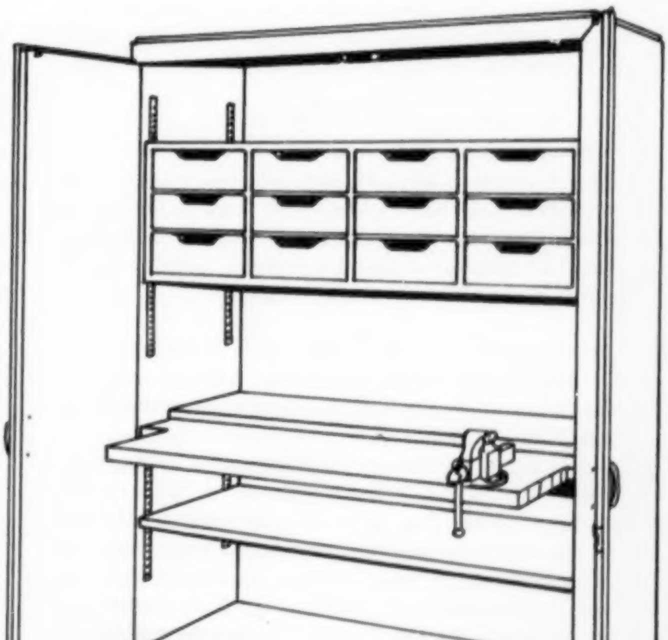


Illustration 65

Above: CAP AND ACCESSORY STORAGE

Dimensions: 62½" x 27" x 83" High

Illustration 67

Right: INSTRUMENT REPAIR CABINET

Another means of storing large instruments is to hang them on pegs fastened to a wall that is cushioned with back rests. The number of pegs will depend upon the number of large instruments in the band or orchestra. This plan is less desirable than the rack or cabinet plans described because it results in unsightly appearance, and there is danger of the instruments being knocked off the pegs.

Percussion Cabinet

Members of the percussion section of a band or orchestra play many different types of instruments, from real musical instruments such as bells, vibraphone, marimba, chimes, xylophone, to "gadgets" for sound effects such as triangles, sleigh bells, bird and train whistles, and numerous other special sounds. It is wise to have all of this small percussion equipment assembled in one place for safe storage as well as for accessibility.

The percussion cabinet should be equipped with rubber casters so that it can be moved easily to the part of the rehearsal room where the percussion section is assembled. It would be wise to have two of the casters with wheel locks to keep the stand from rolling around while being used. It is also suggested that two handles be attached for lifting purposes. Another addition to the cabinet would be drop-leaf extensions on either side of the cabinet top. The shelves should be designed to hold various sizes of cymbals, tom-toms, tambourines, etc. One shelf should be long enough to hold a set of orchestra bells.

Tuning Bars

A well furnished instrumental music room should have two tuning bars, one for orchestra with a pitch of A-440, and one for band with a pitch of B flat-466.2. The bars should be provided with resonating boxes so that the tuning pitch may be heard in all parts of the rehearsal room.

Pianos

Upright pianos may be used in music rooms, but for major musical activities a grand piano should be available if possible.

Upright pianos should be mounted on large, wide, rubber casters, ball-bearing style, or on metal frames equipped with this type of roller casters. Grand pianos should be mounted on a special frame equipped with ballbearing rubber casters, so constructed that the instrument is not raised so much that operation of the pedals is made difficult. Such equipment facilitates movement and pays dividends in helping to keep the piano in tune and in preventing damage to the piano legs and floor.

It is not advisable to purchase cheap pianos. The extent of their daily use and relatively long periods of service are primary considerations. A cheap piano cannot produce a desirable quality of tone, often does not hold its tuning, and is not dependable mechanically. All of these considerations are essential for practical as well as musical results.

All pianos should be tuned to American Standard Pitch, A-440, three or four times a year. It is unfair to ask students to listen to a piano that is badly out of tune, or to ask them to perform with a piano when any appreciable adjustment of tuning level is required.

Risers

All music class pupils must watch their directors persistently while rehearsing or performing, in addition to reading their music and/or words. This is possible only by raising the level of successive rows of seats or by elevating the director by means of a platform. If the director stands on a platform and the students sit on chairs on a level floor, the students are forced to sit in an unnatural position in which the voices of singers and the tones from the instruments are obstructed by the persons in front of them. If the students' seats are raised, they may sit in a natural position and their musical performance is not impaired. Raised seats have the additional advantage of permitting the students to hear one another better than when all are seated on the same level.

Risers may be purchased from commercial dealers. Those available are: for standing chorus (two or more rows), seated chorus, and band or orchestra. The instrumental music risers can be purchased to fit almost any stage or music room. They are of the portable, collapsible type, and the materials of which they are constructed vary from all plywood to a combination of metal and wood. The all-plywood, collapsible models are more portable.

Risers may also be built in the school industrial arts or carpentry shops. It is usually best to build them solidly and in boxlike, portable sections (not too heavy to handle easily) that fit together to form a semicircle. Each step of the standing chorus riser should be about fourteen inches from the front to

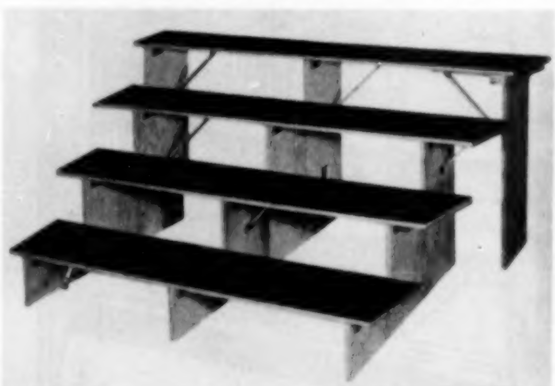


Illustration 68

COLLAPSIBLE CHOIR RISER
Wenger Music Equipment Company, Owatonna, Minnesota

SAMPLE SPECIFICATIONS FOR SCHOOL UPRIGHT PIANOS

(1) *Identity.* Pianos shall have the same name cast into the plate as appears on the front of the instrument. (This shall be the name of the manufacturer making the instrument). In the event the manufacturer makes more than one grade of school piano then separate bids may be entered for each grade manufactured.

(2) *Over-all Size.* Keyboard shall have full seven and one-third octaves, and piano shall be at least 44 inches high.

(3) *Cabinet and Finish.* Cabinet work shall be in accordance with the best approved methods of the leading piano manufacturers. All veneers shall be of good quality, and cases shall be double veneered on the inside as well as the outside. Finish shall be not less than two coats of good grade lacquer or varnish, in addition to the stain and filler, and rubbed to a dull satin lustre.

(4) *Casters.* Casters shall have double wheels of hard rubber or plastic not less than 2 inches in diameter, and shall be of the double ball bearing, swivel type construction.

(5) *Key Bed.* The piano key bed shall be of "panelled" construction, made of kiln dried lumber and measuring at least $1\frac{3}{4}$ inches thick. Underside of key bed shall be at least 24 inches from the floor to allow proper knee room for pianist.

(6) *Keys.* All "natural" keys shall be made of either pine or basswood, with ivory or white plastic tops and ends. If ivory, then nothing less than No. 3 grade shall be used. "Sharp" keys shall be either black plastic or ebonized hard maple.

(7) *Plate.* Plate shall be what is known as "full cast plate" made of gray iron and showing the name of piano manufacturer cast therein. Finish shall be either bronze or silver.

(8) *Back and Pin Plank.* The piano back shall be made of no less than five hardwood posts at least $2\frac{5}{8} \times 3\frac{1}{4}$ inches in cross section. At least three of the posts shall be securely anchored to the plate with "lag bolts." The pin plank shall be laminated with at least four sections of hard maple. It may or may not be exposed. The entire back shall be finished with a good grade of lacquer or varnish.

(9) *Tuning Pins.* Piano tuning pins shall be threaded and properly sized, made of blued steel. Pickled or brass pins will not be accepted.

(10) *Sounding Board, Ribs, Bridges.* The sounding board shall be of close-grained, hard texture mountain spruce that has been quarter-sawed.[1] There shall be a uniformity of grain and color throughout its entire width. All ribs shall be of the same material, and shall extend beyond the edges of the sounding board, where they shall be securely glued into a slot in the lining of the back. Sounding board shall be properly crowned in accordance with the demands of the scale and for correct "down bearing" from the strings. Bridges shall be of hard maple, made sufficiently thick and wide to maintain strings on an adequate "up bearing" as well as "side bearing." Bridges also shall be glued to the sounding board with hot hide glue and further secured with wood screws from the back of the sounding board. All such wood screws shall have maple "sounding board buttons" under their heads.

(11) *Action.* The action shall be full size. Hammer shanks shall be at least $3\frac{7}{8}$ inches long. Both the under and top felts on the hammers shall be of the highest grade hammer felt. Hammer weight shall be in keeping with the scale design, but not less than a size 12 in weight. Beginning at the largest hammer in the base section, at least 58 hammers shall be stapled through the felt. There shall be no substitute materials, such as plastic, used in place of standard hard rock maple. All connections shall be bushed and pinned. Bushings shall be made of the best grade of wool felt cloth. Entire action shall be mothproofed.

(12) *Musical Tone.* The piano shall possess, throughout the entire range of the keyboard, a musical tone of sufficient depth and power to warrant the written approval of the School Board and also the person who is directly responsible for supervision of the music program. *No piano shall be accepted which fails to qualify for this written approval, even though such piano complies with all other requirements and may be entered as the lowest bid.*

Note: For various reasons pertaining to space requirements, mobility costs, and other factors, the upright style piano affords a practical utility instrument for general classroom use. Obviously, for artistic and educational purposes it is desirable to have a grand piano in the auditorium, also one in the chorus room—and perhaps in the instrumental room and elsewhere in the school, if possible. The sample specifications for upright pianos given here were prepared for the Music Department of Western Michigan College of Education, Kalamazoo, by the head of the department, Elwyn Carter. Each school can, with the aid of its staff and available consultants, make its own specifications, taking into account special conditions and factors which may indicate need for considerations such as keyboard cover locks, size of racks, advisability of using dust covers, and possibly other items not included in the schedule reproduced here.

[1] A sounding board of laminated wood, regarded as an acceptable alternative for the solid sounding board, offers the advantage of resistance to temperature and humidity changes which may cause warping or cracking.

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back, and the length and number of sections will depend on the size of the chorus and auditorium stage. Each succeeding step should be approximately eight inches higher than the preceding one. The risers for a seated chorus should be similar to the ones for standing chorus but should be about thirty inches wide from front to back, i.e., for each level of chairs. The number of elevations depends upon the number of students in the chorus as well as upon the size of the music room or stage.

Risers for the band or orchestra are similar to those for the seated chorus, and for the average music room or stage there should be three or four elevations in addition to the floor level, with each elevation six to eight inches higher than the preceding one, and each elevation at least four feet from the front to back. In building these sections care should be taken not to build individual sections too large since the excessive weight would make it difficult to move them from place to place. Larger pieces are also more difficult to store.

It has been proved a wise procedure to build in permanent risers in music rooms, according to the above specifications. Those for the chorus would, of course, be of the seated chorus style. If the music groups become accustomed to risers in their rehearsal rooms, it aids them considerably if portable risers similar to those in the music rooms are available for concert performances.

School-Owned Band and Orchestra Instruments

Certain musical instruments which are necessary for every band and/or orchestra should be provided by the school, inasmuch as they are useful only in the band or orchestra (not especially suitable for solo playing), are expensive, and are often heavy and cumbersome to transport. Parents often cannot be induced to purchase such instruments for their children when the more desirable solo instruments are better known, less expensive, and easier to transport. Following is a list of these instruments and the probable number desired:

String bases. From four to ten, depending on the size of the school music program.

Tubas. From four to eight sousaphones for the band, and one recording bass for the orchestra.

Timpani. One set for each school. Pedal tuning.

Bassoons. Two or more. Heckel system.

Oboes. Two or more. Conservatory system.

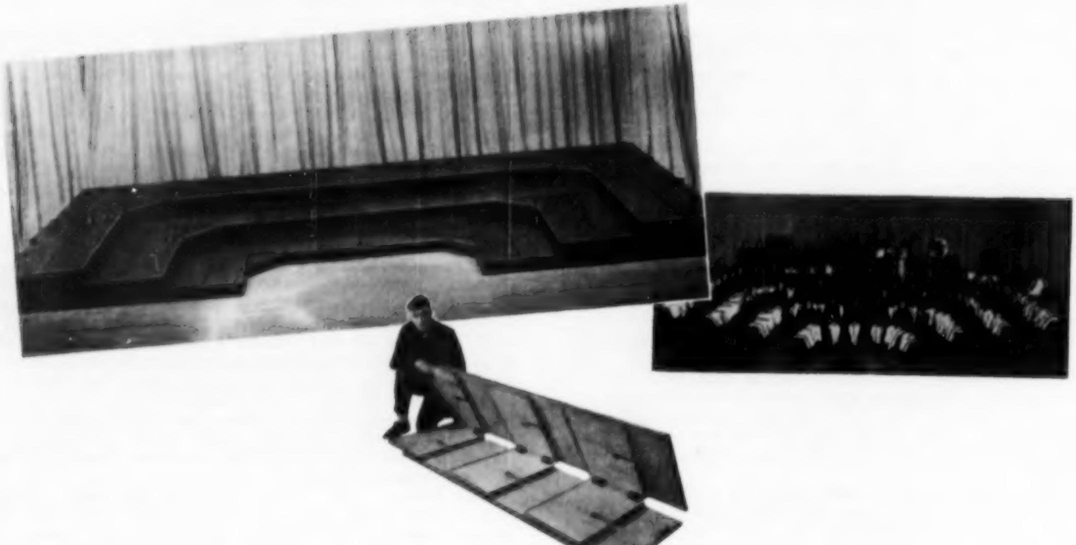


Illustration 60

COLLAPSIBLE BAND RISER

French horns. From four to eight. Two double, two single.
Violoncellos. From four to twelve.
Violas. From four to twelve.
Harp. One for the large concert band or orchestra.
Celesta. One for the large concert band or orchestra.
English horn. One for the large concert band or orchestra.
Alto clarinets. From two to four.
Bass clarinets. From two to four.
Bass drums. One each for band and orchestra.
Baritone saxophones. One or two.
Bass saxophone. One.
Chimes. One set.
Vibraphone. One—three or four octaves.
Xylophone. One—three to four and one-half octaves.
Marimba. One—three to four and one-half octaves.
Euphoniums. From two to four, preferably four valve.
Contrabassoon. One for the large concert band or orchestra.
Concert snare drums. From two to four.
Field snare drums. From two to six.
Fluegelhorns. Two.
Bass trombones. One or two, with F attachment.
Percussion traps. One or two complete sets.

School-Owned Instruments for the Elementary Classes

In some school systems where excellent bands and orchestras have been developed, systems have been worked out in which the schools own some or all of the various band and orchestra instruments. These instruments are loaned or rented to the students for trial periods, in order to get large numbers of students started on musical instruments. This plan is often started in the elementary schools and carried over into the junior and senior high schools. Because there are certain problems in scheduling many different kinds of instruments, and because the basis for the instrumenation depends mainly on the violin, cornet, and clarinet, these instruments should be supplied in numbers and put in the elementary schools. Many school systems furnish the following instruments in the elementary schools:

Violins. Quarter, half, and full size.
Violas. For the larger students, some schools use full-size violins strung as violas in order to teach the alto clef.
Violoncellos. Quarter, half, and full size.
Bass viols. Quarter, half, and full size.
Flutes and piccolos.
Oboes. With simplified systems of fingering.
B-flat clarinets.
French horns. Double, single, and possibly mellophones.
Cornets.
Trombones.
Baritones.
Tubas. Small upright E-flat tubas.
Full percussion equipment.

Miscellaneous Equipment

Movable coat and hat rack—for use in the music unit during the evening activities. *Flag and stand*—for the large rehearsal room used also as a small auditorium. Large size roll-up *picture screen. Curtains and heavy blinds* to darken the large rehearsal room. *Tuning bars,* metronome, radio, phonograph, television, recording equipment, duplicator, stroboscope (chromatic), motion picture projector (with sound) opaque projector, film strip projector, standard lantern slide projector, micro-projector, portable amplifying (public address) system, etc.

Teacher's Office Equipment

Desk and swivel chair, filing case, bookcases, shelves, coat rack, closets, typewriter, telephone, large mirror (for teaching purposes), a cabinet for music room and locker keys, chairs for visitors, pictures and other articles to make the room attractive.

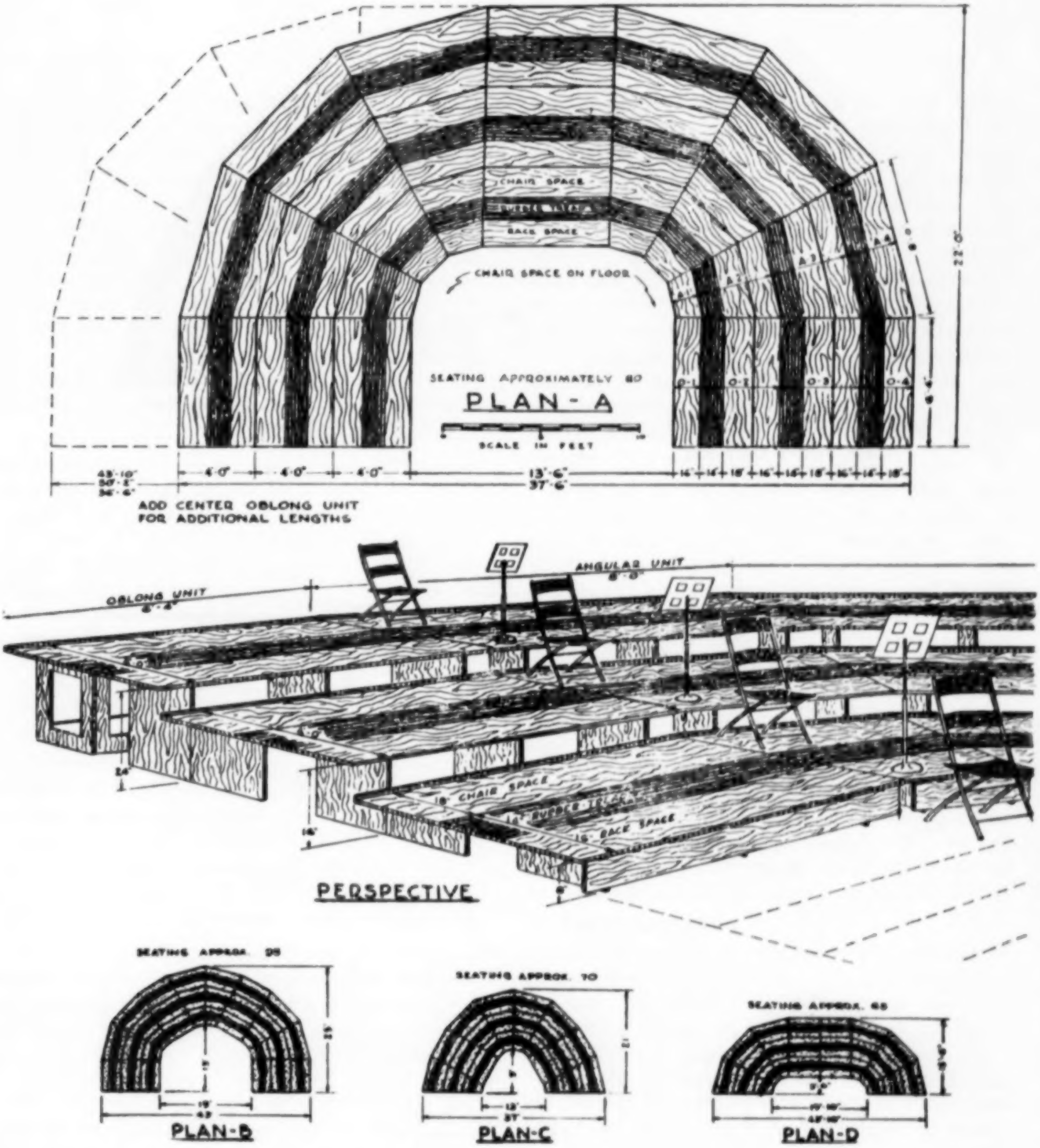
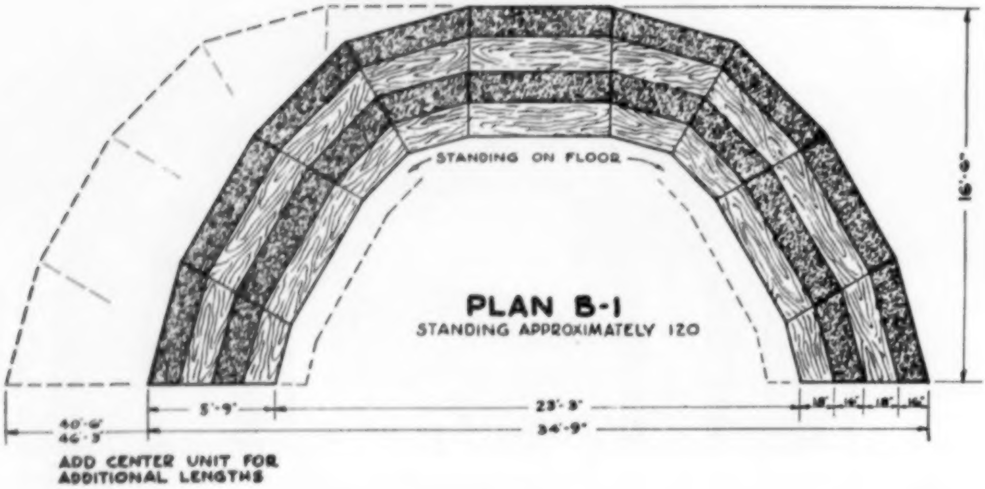
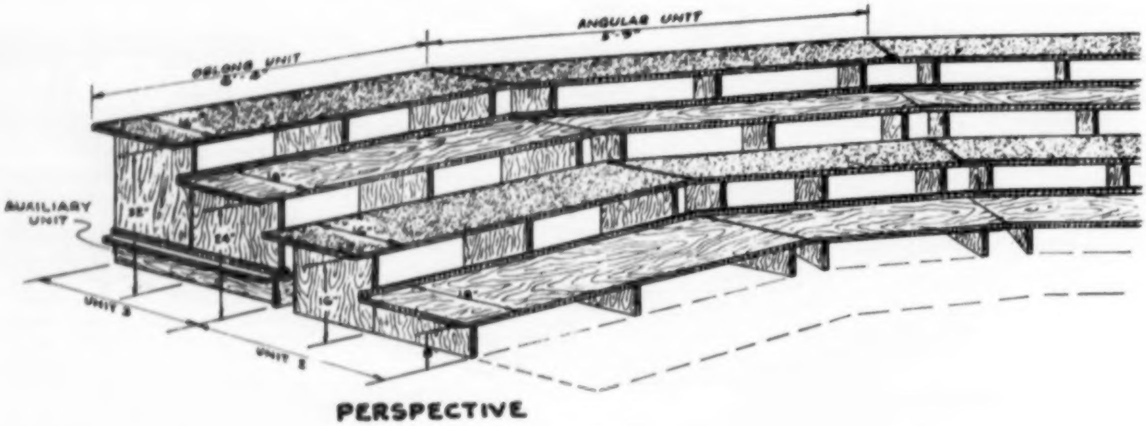


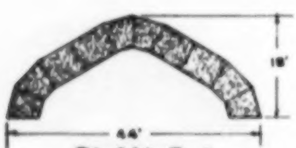
Illustration 70

RISER PLANS



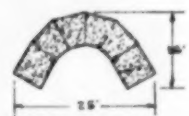


PERSPECTIVE



PLAN B-2
STANDING APPROX. 145

PLAN B-3
STANDING APPROX. 125



PLAN B-4
STANDING APPROX. 80

Illustration 71

RISER PLANS

XI

Audio - Visual

The phonograph, as the most used of the music room's mechanical equipment, should be chosen with great care. Instruments are available in a very wide price range, and the selection will naturally depend upon the money available and the use to which the instrument is to be put. Certain minimum standards for school use are suggested, however: an electric motor of such power and design as to rotate the turntable at a constant speed; provision for 78, 45, and 33⅓ rpm speeds; an amplifier of sufficient power to fill the room without distortion; and a loudspeaker or speakers capable of reproducing the full range of modern records.

In choosing such an instrument the teacher without special training in electronics equipment should check the following: the turntable should be steady enough at all speeds to reproduce piano music without "wow" or "flutter." It should not be necessary to turn the volume control to the limit to produce sufficient volume (minimum output of 5 watts), since the reserve power is necessary to avoid distortion. Pickup arms, in the cheaper machines at least, should be of the crystal type as being the most dependable, although in the higher priced field there are excellent pickup arms of other types. Generally, a twelve-inch speaker in an enclosure of six to eight cubic feet has been accepted in the past as the minimum standard for reasonably high fidelity, which has ruled out table models except where portability is a factor. Purchasers will do well, however, to investigate recent new designs in speakers and enclosures which give promise to produce in table models a fidelity at least equivalent to the average console model.

In the absence of special equipment for testing, a trained ear listening to the instrument *in the room and under the conditions in which it is to be used* is a sufficiently reliable test, but the purchaser should hear some of the more elaborate high fidelity systems to establish a standard of perfection.

The 33⅓ rpm long-play record has become the standard for high quality recording, but the older 78 rpm records will have considerable use for some time to come, and there are some situations, particularly involving very short selections, where the 45 rpm records are desirable. Therefore a three-speed player becomes a necessity.

Radio

The choice of a radio receiver will depend first of all upon the type of transmission available. AM radio has been the standard since the early days of broadcasting, but the newer FM radio has a tremendous advantage in freedom from static and in greatly increased fidelity. There is a corollary disadvantage in that FM transmitters do not carry great distances, and in some parts of the country FM transmission has developed slowly. Many of the large cities have FM stations both of a commercial and of an educational nature, and the Federal Communications Commission has set aside certain channels for educational use. In view of the fact that combination AM-FM radios are not greatly higher in cost, they are recommended for school use wherever FM transmitters are presently available or planned for the future.

In rating radios, engineers speak of their three principal characteristics as ***sensitivity***, the ability to bring in distant signals clearly; ***selectivity***, the ability to separate one station from others on adjacent wave lengths with a minimum of interference; and ***fidelity***, the ability to reproduce sounds throughout the entire audio range with equal clarity. For practical purposes it is generally necessary in designing a medium-priced radio to sacrifice one or more of these qualities to the others, and radios of different brands and models are apt to vary considerably in the relative success in which these three characteristics have been achieved. To the musician, ***fidelity*** is of the utmost importance and the best choice for any classroom use is the radio which is designed so that sensitivity and selectivity are adequate for the particular conditions of the location, but not stressed at the expense of fidelity.

Small table model sets are not very satisfactory in the matter of fidelity of tone. If portability or low cost make the choice of such instruments necessary, radios with substantial wooden cases are apt to be superior to the more common plastic types.

Generally speaking, radio sets should operate on 110-115 volt AC current, with an undistorted output of not less than 5 watts (the output rating should not be confused with the rating for current consumption, which is also expressed in watts). The tests for fidelity mentioned above for phonographs can also be applied to radios.

No report on radio would be complete without mentioning binaural broadcasting, which has been successfully tried in several communities. Binaural broadcasting uses two transmitters, which each broadcast a given concert, using slightly different micro-

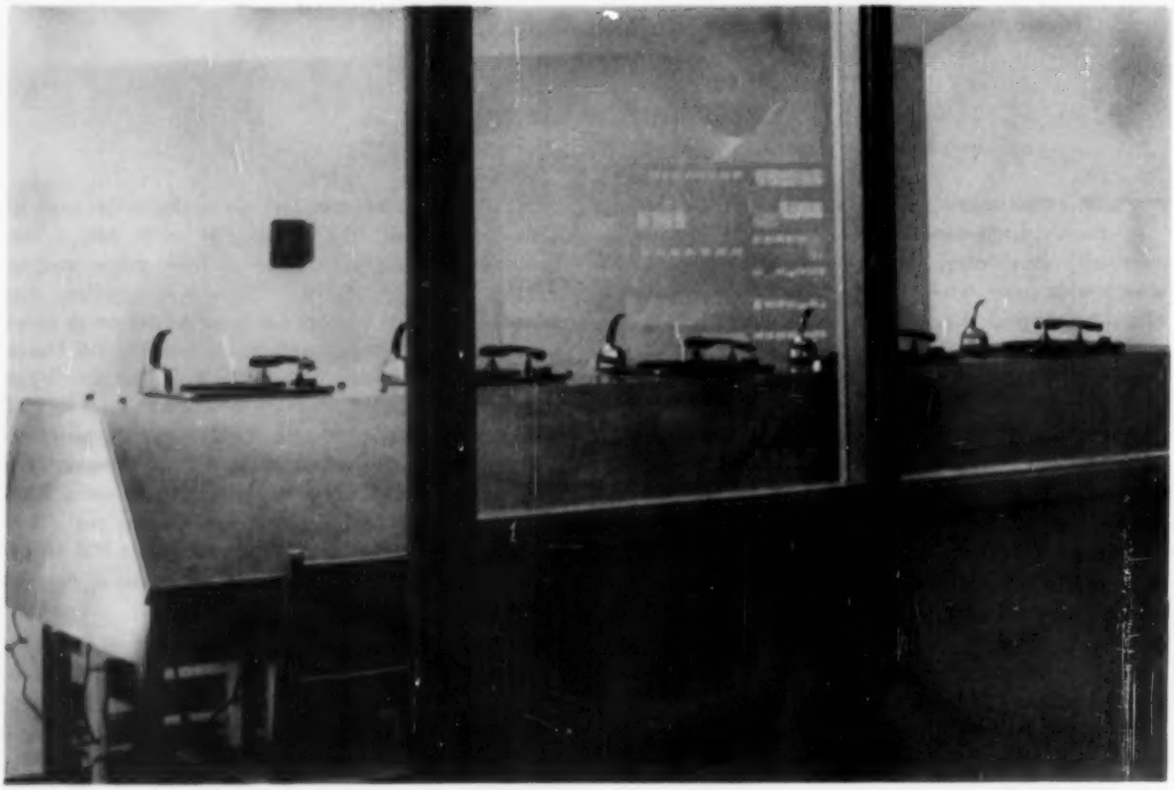


Illustration 72

LISTENING ROOM
Partial Interior View

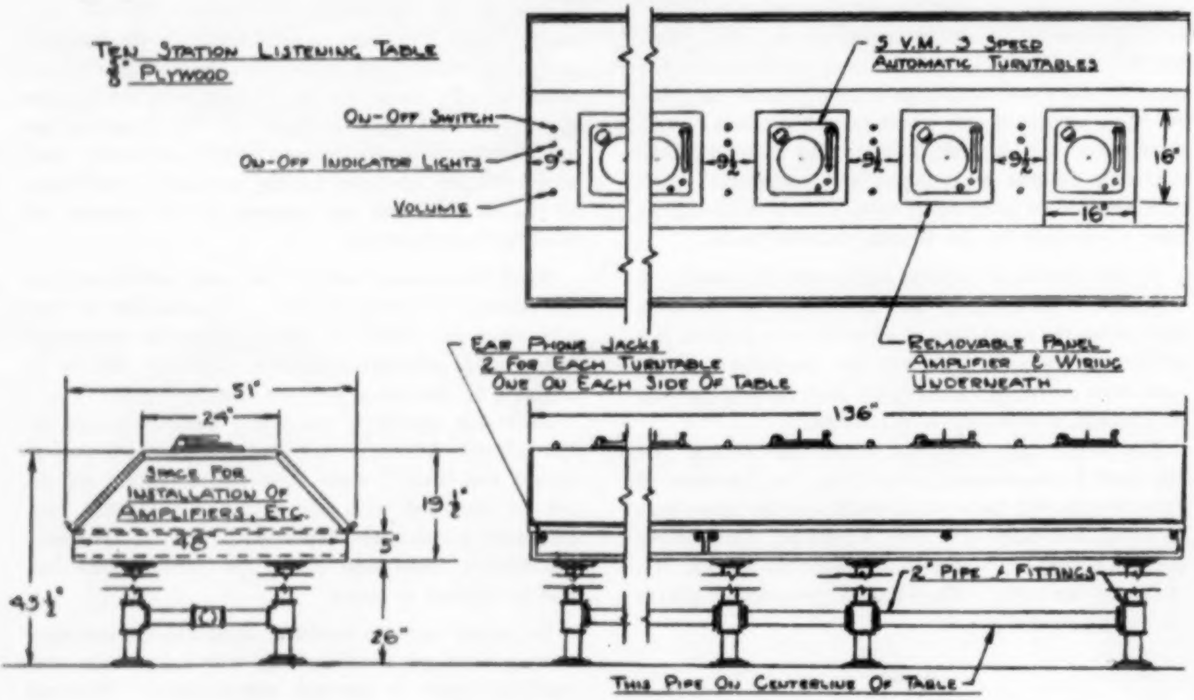


Illustration 73

PLANS FOR LISTENING ROOM

phone arrangements in the auditorium. Using two receivers spaced in opposite corners of the room, one receiver tuned to one participating station and the other receiver tuned to the second station, the listener is able to feel the effect of actual "presence" at the concert. Binaural broadcasting gives a much truer reproduction of the concert than it is possible to perfect with traditional one-station transmission.

Combination Radio-Phonograph

As its name implies, the combination radio-phonograph is the result of the building together in one cabinet the radio and the phonograph. This makes a product that is cheaper in price and, also, as one complete instrument, requires less space than would two separate units. The same amplification system serves both the radio and phonograph. Usually the combination set is a better purchase for the music departments than is the purchase of separate instruments. With the amount of money that would be required for two instruments, it is possible to obtain one that combines the desirable points of both but is of much better quality.

High-Fidelity Reproducing Equipment

A new development in the phonograph field is the assembling of custom-built phonograph equipment of a fidelity undreamed of a few years ago. High fidelity is not the result of any one new innovation, nor is it achieved by the improvement of a single component, but the careful selection and improvement of each part of a reproducing system, and the satisfactory matching of each part in relation to the others. There is theoretically almost no limit to the accuracy of reproduction which can be secured, but each additional gain is matched by a corresponding increase in cost, so that the ultimate choice, as always, depends upon balancing theoretical perfection against the demands of the budget.

Purchasers of such systems customarily choose the various components separately and assemble them in custom-made cabinets, or build them into the room itself. The components include the pick-up arm, the motor and the turntable, the amplifier, the power supply, and the loudspeakers (often two or more) with their accompanying enclosures. Added to these are often such refinements as pre-amplifiers and equalizers of various sorts. Some of the nationally known manufacturers are also beginning to supply such systems as complete units. For schools able to afford the best in equipment, such systems should be investigated, although in the present very rapid state of development any specific information becomes obsolete in a few months. One good source of information is the magazine *High Fidelity* (published by Audiocom, Inc., Great Barrington, Mass.).

Recording Equipment

Of the three types of recording machines, the magnetic tape recorder, the wire recorder, and the older disc recorder, the tape recorder has almost completely supplanted the other two for general school use. It is cheaper in operation, with tapes re-usable hundreds of times, playable an indefinite number of times without loss of quality, and able to be stored permanently. It is much easier to operate than the disc machine and has higher fidelity than either the disc or wire recorder under normal classroom conditions. Tapes may be edited, cut, erased, and added to almost at will.

Tape recorders are available which operate 3¾, 7½, and 15 inches per second, as well as those allowing the selection of either of two speeds. Machines are also classed as single or dual track, the latter type using half the width of the tape for one recording, with a second recording available by reversing the reel. In general, the minimum standards for the fidelity needed in musical work demands a 7½-inch single track machine. The 3¾-inch speed, while satisfactory for some speech work, does not have sufficient fidelity for music. The 15-inch speed offers extremely high fidelity, but at the disadvantage of bulkiness and greater cost, and is necessary only if the greatest fidelity is demanded. On a dual-track machine the signal strength is weaker and, when played back, the noise level is consequently higher. However, the chief difficulties of the tape recorder for music lie in the "wow" and "flutter" introduced by the drive mechanism particularly in the 3¾-inch speed. This should be checked carefully as mentioned above, by the recording of piano music.

Tape recorders can be secured in almost any price range, but they tend to group themselves into three classes: the cheapest group featuring economy, portability, and extreme simplicity of operation, at the expense of loss of fidelity; a middle group of somewhat heavier machines with additional controls and refinements that make for greater accuracy and versatility; and the expensive, high fidelity machines, usually comprising separate units for recording heads, amplifiers, and speakers, appropriate for the finest work. It is recommended as a minimum that a school possess one instrument in the middle range, with perhaps a second low-priced instrument for student use and easy portability.

Besides their normal use in recording from a microphone, recorders should also be wired to record radio programs for study purposes. Most recorders are now so equipped, and any radio repairman can make the necessary changes in the radio and phonograph to allow for quick plug-in connections. Where such alterations are made it is desirable to make provision for silencing the radio or phonograph speaker and monitoring the incoming program through the speaker of the recorder. After a program is under way, and

the necessary adjustments have been made, the recording speaker can be turned off and the remainder of the program recorded in complete silence. This is a considerable convenience when it is necessary to record a program while other activities are being carried on in the same room.

Plastic tape is sufficiently better in durability and fidelity to warrant the somewhat greater initial cost over paper tape. Remote control foot switches are an extra refinement well worth the slight extra cost. Provision should be available to operate an external loudspeaker for greater fidelity in playback. *Binaural* or *stereophonic* tape recorders, recording through two microphones to two separate sound tracks and reproducing through two loud speakers or two-channel headphones, increase fidelity through giving a sense of direction of the various sounds in music, as they are heard in "live" music through the two ears of the listener. At the time of this publication binaural recorders using two-channel headphones are useful and desirable in library listening facilities for such recordings as are available or can be made of local musical performances. Stereophonic, or two loudspeaker reproduction, is largely in the experimental stage but gives considerable promise for the future.

The use of the disc recorder in schools is now limited almost entirely to the copying of tapes onto discs for use on home phonographs. Large schools may wish to have a disc recorder for the purpose, and neither the cost nor the operational techniques are insurmountable. Unless, however, a great deal of work is to be done the excellent tape-copying service of commercial agencies will probably be cheaper for the average school than maintaining a disc recorder of its own.

Television

An important development of the past few years has been the phenomenal increase of interest in non-commercial educational television. The National Citizens Committee for Educational Television reports that it expects 27 non-commercial educational television stations will be on the air by the end of 1954. A significant number of universities, colleges and public school systems are expected to set up equipment for making kinescope recordings. Since television is accepted as a most formidable teaching tool, music departments throughout the country should keep informed concerning the growth of non-commercial educational television, and should be learning television techniques so that they may take full advantage of this important medium when educational television stations are established in their communities. In the meantime, educators should not neglect the opportunities afforded them by the commercial stations, many of which are happy to give time for music appreciation programs.

Tuning Devices

The standard minimum tuning equipment for instrumental music rooms is a well-constructed tuning bar with resonator, tuned to A-440 cycles per second for orchestra and Eb 466.2 for band. Several more elaborate electronic devices have been produced which are highly useful.

The *Lektrotuner* is a vacuum tube instrument which produces a constant A or Bb (both in the same instrument) in two different tone qualities and a wide dynamic range through a built-in speaker. It is designed to a standard of A-440 but can easily be adjusted to a variation of about 5 cycles above or below. Its advantage over the tuning bar, in addition to its adjustability, is that the tone can be produced continuously for any desired time.

The *Stroboconn*, a chromatic stroboscope, was developed primarily as a measuring device for testing the intonation of instruments. The Stroboconn gives a visual indication of the pitch of any tone of the chromatic scale, and has been found to be adaptable to a wide variety of uses where accurate measurement of frequencies is involved. Some teachers of music, both vocal and instrumental, have used this instrument successfully as a means of ear training. It can be used also as an aid in the teaching of harmony, theory, physics of music, and kindred subjects.

Another visual tuner, the *Tone-o-graph*, adapts the stroboscopic principle to a simpler instrument giving visual indication of a standard Bb, and is very useful in situations not requiring the greater adaptability—and corresponding greater cost and complexity of operation—of the Stroboconn.

Electric Metronomes

Several electric metronomes have been developed that have proved to be a great help to music teachers. Different pulsations are easily and accurately obtained by a simple adjustment of a knobbed dial. This electrical device is a definite improvement over the old spring-driven pendulum type. Some electric metronomes are available which give, in addition to the aural indication, a visual indication by means of a small beam of light. In conditions of large volume of sound (e.g., drum practice) this visual indication is of considerable value.

Projection Equipment

It is assumed that each music department will have available, usually through the school audio-visual department, the conventional movie and still-picture projection equipment. The types deserve special mention, however, as their particular adaptability to music classes is often overlooked.

Opaque Projector

This device projects an entire page, either from a book or unmounted material, on a screen in the original color or black and white. Earlier models

were cumbersome to use, due to such conditions as extreme size, the smallness of the size of the page projected, the complete darkness of the room required, and particularly the difficulty of maneuvering the material into position quickly. Recent models are increasingly able to overcome these objections, and it is now possible to choose a model which will project a full-sized sheet of music, making it possible to project scores, pictures, and even student exercises in harmony. If the latter use is intended, a few of the newer projectors have provision for the insertion of a pen or pencil so that the actual correction of a note may be shown on the screen.

Large-slide Projector

The projector using 3½ x 4 inch slides is one of the earliest of audio-visual devices. For the projection of slides and strip-films it has almost entirely been superseded by the smaller and more convenient 2 x 2 inch projector. The former possesses one important advantage in that slides can be handmade very simply and quickly either by teacher or student for the projection of charts, words of songs, and the like. Slides may be made in either of two ways: on etched glass with ordinary pencil or pen (or colored with special crayon or paint); or typed on cellophane and mounted between heavy cover glass. The process is much simpler than the photographic method necessary for the 2 x 2 slides, and may be very quickly mastered without technical knowledge.

Mimeoscope

An illuminated drawing board used for tracing stencils from a formation drawing. Copies of the band formations can then be mimeographed and given to each member of the band, a valuable aid for the marching band director.

Other Electrical Equipment

Numerous other electrical devices have been invented and are being used by music educators with success for certain specialized tasks. A few of the more important are:

Audiometer: An instrument for testing the ears for hearing loss.

Sound Level Meter: For measuring sound levels and noise levels.

Spectrum Analyzer: There are several types which give some quantitative or visual display of tone quality.

Audio-Frequency Oscillator: Produces any desired frequency or intensity and can be adjusted to produce small increments in pitch.

Oscilloscope: Presents a visual display of the waveform. Has use as a demonstration device and some merit as a teaching aid.

Phonoscope: An instrument which gives a visual trace of location on a phonograph record. Useful for study of form and analysis of recorded selections.

General Sound Distribution Systems

The equipment by which radio programs, phonograph recordings, and locally originated programs and announcements are distributed throughout the school is usually shared by the entire building and is therefore only partially the responsibility of the music department. Since, however, considerable use of such equipment is made by music teachers, it is important for them to be well-informed in its selection and use.

A central sound system distributes, from a central location either in the school offices or audio-visual center, radio programs, phonograph recordings, tape recordings, or live programs originating from any of several locations where microphone outlets are provided. Most such systems are also equipped so that whatever is occurring in a classroom may be monitored from the central switchboard, and the equipment also can be used as a two-way communication system between the practice room or classroom and office. The system can also be used to provide public address amplification in school auditoriums and gymnasiums.

All equipment should be purchased from a well-established manufacturer and installed by engineers experienced in such work. Some of the points on which music teachers should check when such equipment is under consideration are listed below.

Microphone outlets should be provided in all large rehearsal rooms so that programs originating in the music department can be fed into the system.

Loudspeakers in the music department, auditorium, and other principal classrooms should be of sufficient size and quality to preserve the fidelity of musical programs. This specification is especially important since the smaller and cheaper speakers which may be entirely satisfactory for spoken announcements are often inadequate for musical reproduction.

Microphones should be of high quality and adapted to the purpose for which they are to be used. For public address purposes cardioid microphones, with their comparative freedom from feedback, are standard.

Tape-recording input and output channels should be provided. That is, it should be possible to take a tape recording off the air at any hour, and feed it back into the system at a more convenient time. Most of the better new systems have such a provision, and with the wide use of tape recordings at present it is a mistake to omit it for reasons of economy. Older installations can be easily adapted to the purpose.

Portable Public Address Systems

As with the central sound systems, portable systems will usually be shared with other departments, but as such equipment may be used for occasions such as outdoor band concerts and musical performances in auditoriums not permanently equipped, the same supervision should be exercised in its selection as with the central systems. Microphones should be of the cardioid type and of high quality. The ampli-

fier should have sufficient reserve power to reproduce music without distortion. Amplifiers are rated in wattage of output, and a fifty-watt amplifier should be the minimum for outdoor use and large auditoriums. Loudspeakers are available in many types, but many of them designed for spoken announcements are unsatisfactory for musical use. High quality speakers mounted in bass-reflex baffles are generally most satisfactory for musical use where extreme volume is unnecessary, and where difficult problems of microphone placement do not accentuate their tendency to feedback. In conditions involving these difficulties, horn-type speakers may be necessary, but they must be selected with great care, as many horn-type speakers have poor fidelity characteristics.

Of considerable use to the drilling of the marching band is the light, self-contained, battery-operated amplifier which may be carried by means of a shoulder-strap and used for directions and announcements. It is of no use for musical amplification, but its extreme portability and ease of operation makes it a valuable rehearsal aid.

Intercommunication and Monitoring Systems

Where a number of practice rooms are to be in use at one time it is desirable that the teacher be able to supervise the work of the practice rooms from his office. If high fidelity reproduction is necessary, this is best accomplished by an installation of a small central sound system similar to the large sound system described in a previous section. The switchboard can be installed in the director's office or other similar location. Since, however, most of such use will be in the nature of casual inspection, with the final polishing done by the teacher in the room, considerable cost can be saved, and simplification of operation achieved, by the installation of an inexpensive intercommunication system such as is used in business offices. Such a system is based on a unit consisting of a compact loudspeaker which can be reversed and used as a microphone by the flick of a switch. A number of variations in application can be worked out by engineers supplying such equipment, but basically the system consists of *master stations* placed in directors' offices capable of calling or listening at will to any other station; and *staff stations*, placed in the practice rooms, capable of communicating only with the master stations.

In the simplest of these systems, consisting of one master station and one to ten staff stations, the staff stations cannot originate calls but can be heard only when the proper switches are actuated at the master station. It is possible, however, for equipment to be arranged so that the staff stations may originate calls to the master station. Experience indicates that the latter feature is desirable, since students accustomed to the use of the equipment are likely to request assistance from the director if calling facilities are available. Where practice room facilities are shared by two or more teachers with separate offices it is possible to install a combination of two or more master stations and any number of staff stations, or a system consisting entirely of master stations, at, of course, greater cost.

The fidelity of the intercommunication system of this type is not very high, but is sufficient for the average use to which it is put.

Moving Picture Techniques

With the coming of third dimensional moving pictures, it is only natural that sound engineers became concerned with recording techniques that would give sound more depth and color. The result is the development of *binaural* and *stereophonic* recording. It has become more or less common practice to call *binaural* recorders those which use two channels on a single tape. For the playback split earphones are used, the right ear hearing only the right channel, and the left ear hearing only the left channel. *Stereophonic* recorders use either two or more channels, which are reproduced through the use of the same number of appropriately spaced speaker systems. A better approximation of realism is obtained by newly developed three-channel systems. Commercially, four-channel and six-channel systems are used successfully for providing stereophonic sound reproduction for auditorium use.

Illustration 74

AUDIO-VISUAL CLASSROOM

Equipped with lightproof shades, risers, screen (permanent, not shown), and projector. University of Idaho, Moscow

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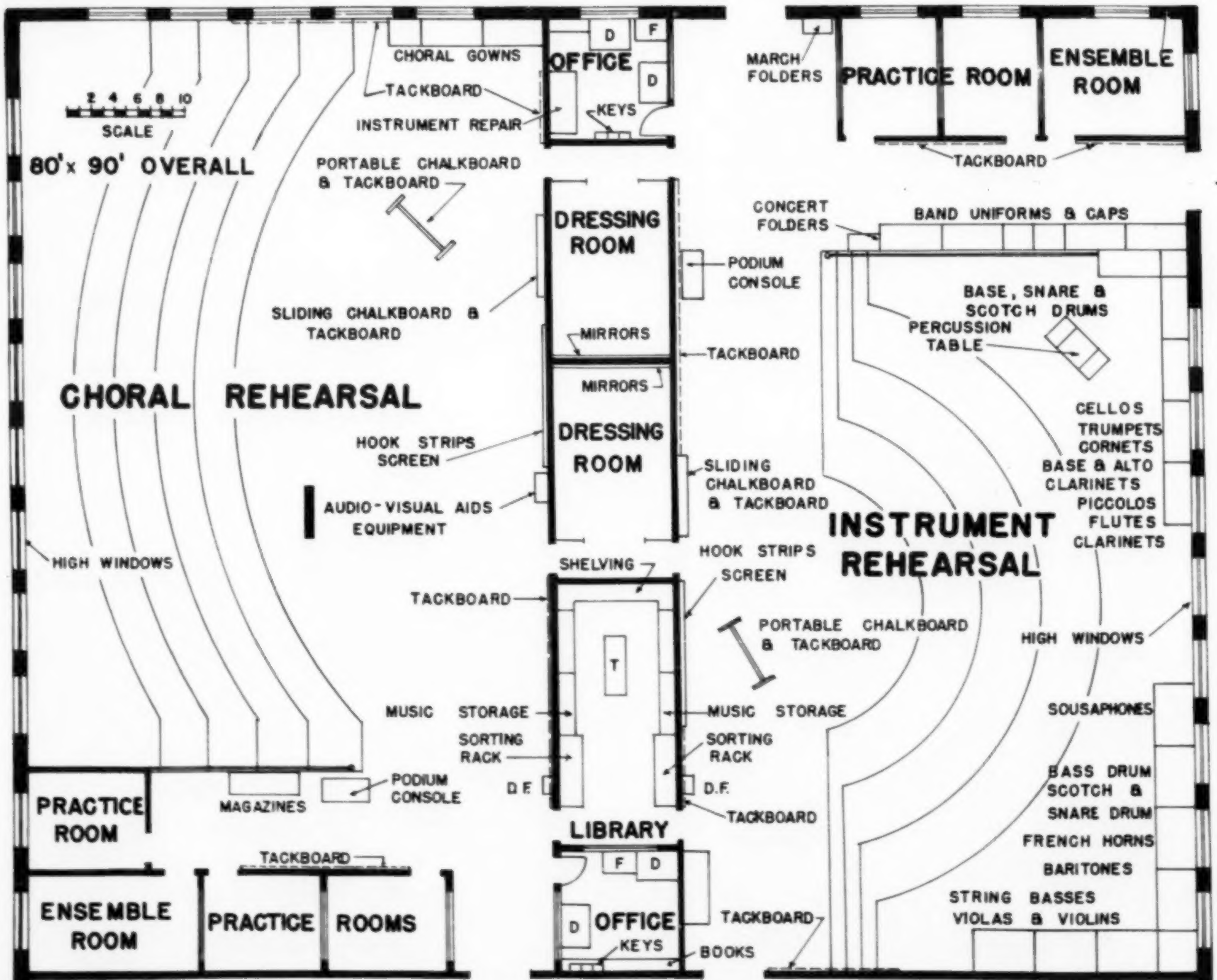


Illustration 76

PLAN FOR A TWO-TEACHER MUSIC DEPARTMENT

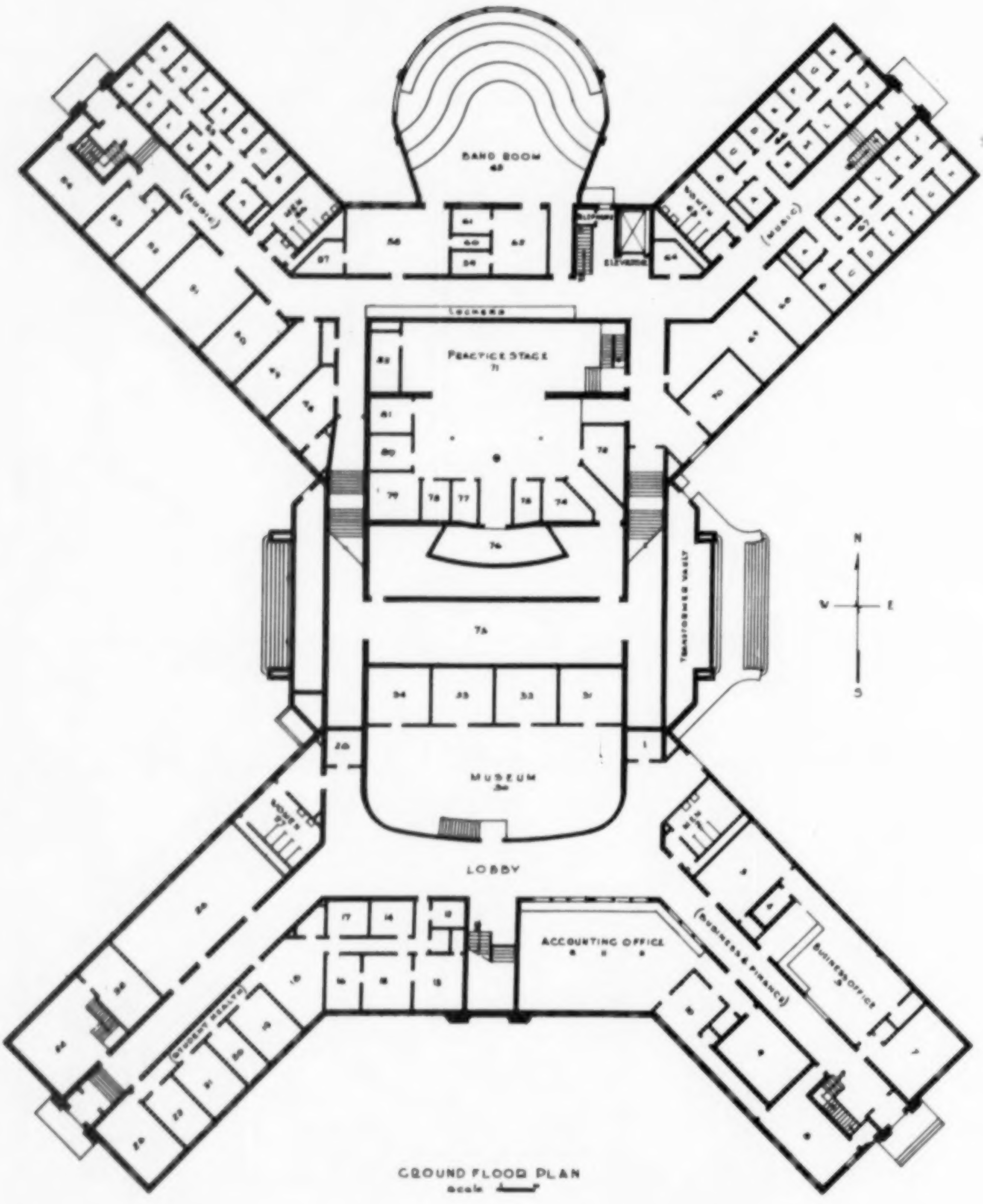


Illustration 77

FRASIER HALL
Ground Floor Plan, Colorado State College of Education, Greeley

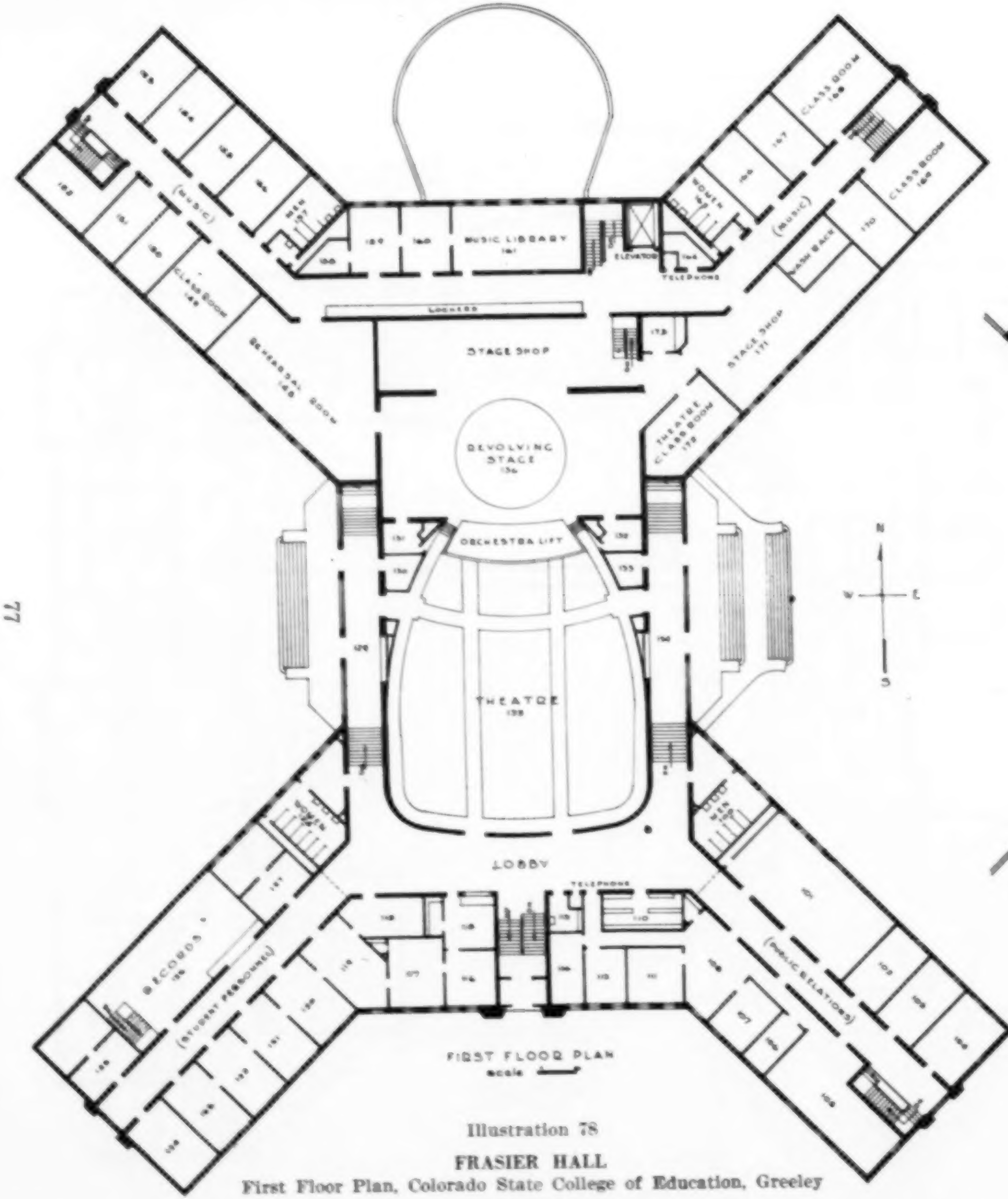


Illustration 78

FRASIER HALL

First Floor Plan, Colorado State College of Education, Greeley

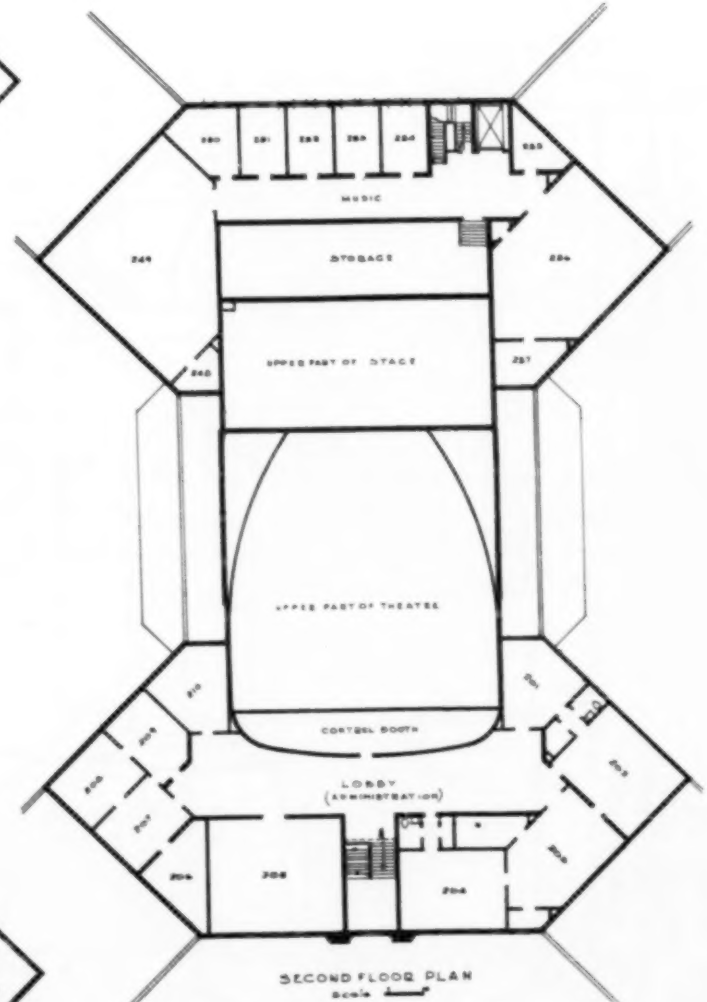


Illustration 79

FRASIER HALL

Second Floor Plan, Colorado State College of Education, Greeley

Illustration 80

MUSIC BUILDING

Ground Floor Plan, Florida State University, Tallahassee

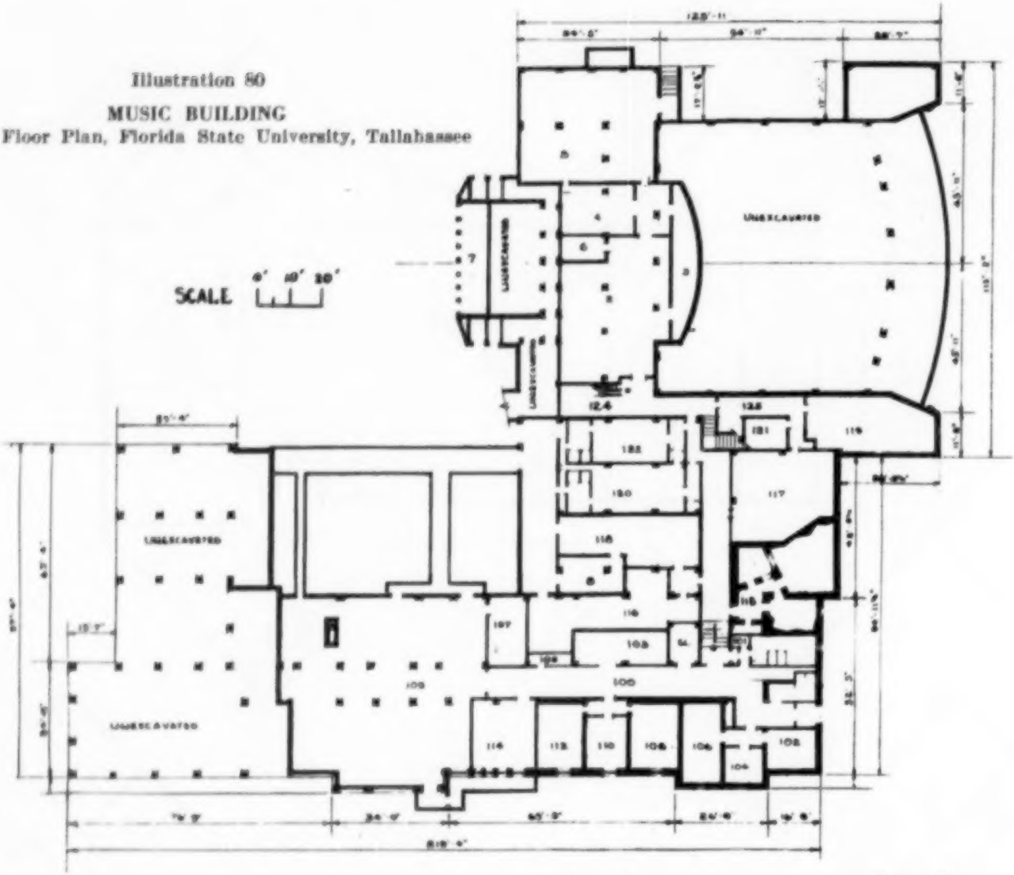


Illustration 81

MUSIC BUILDING

First Floor Plan, Florida State University, Tallahassee

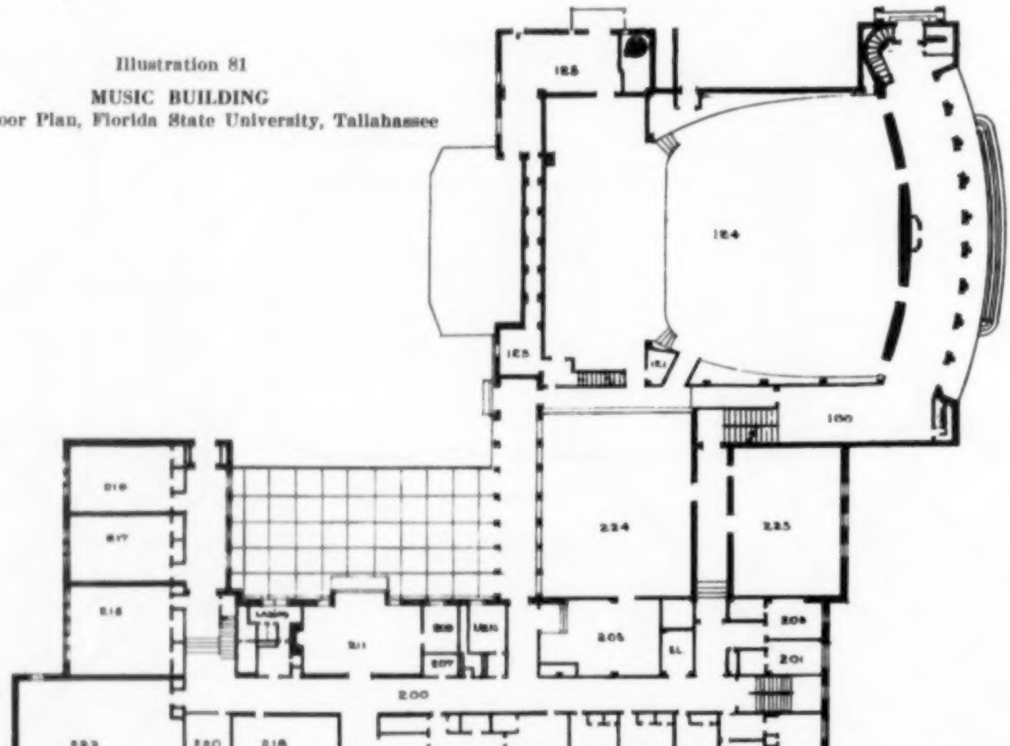


Illustration 82

SPECIFICATIONS

Florida State University, Tallahassee

Amphitheater. **Seats 900—folding metal seats, excellent acoustics.**

Classroom Area. **Five large rooms on the second floor. The sound laboratory in the basement contains the broadcasting studio and control room, tape recorders, and Stroboconn.**

Private Teaching Studios. **Thirty-four are located on the third floor (sound control featuring non-parallel walls and floating floors). Seven private studios are located on the first floor (including three pipe organs and one electric organ).**

Practice Area. **Seventy-three individual practice rooms (smaller than teaching studios but similar construction).**

Library. **Located on the third floor. Houses musical scores, technical books, periodicals, recordings (branch of the main university library), seven multiple earphone record players, three portable players. Five listening rooms in the library.**

Instrumental Room. **Has non-parallel walls and floating floors.**

Choral Room. **Humidity controlled to meet the demand of a group of 25 to 125 people.**

Music Hall. **Seats 542; contains four-manual pipe organ. Is mainly a recital hall but the full-size stage is used for stage productions. The seats are acoustically upholstered. The complete music building is soundproofed and air conditioned.**

Illustration 84

MUSIC BUILDING

Second Floor, Florida State University, Tallahassee

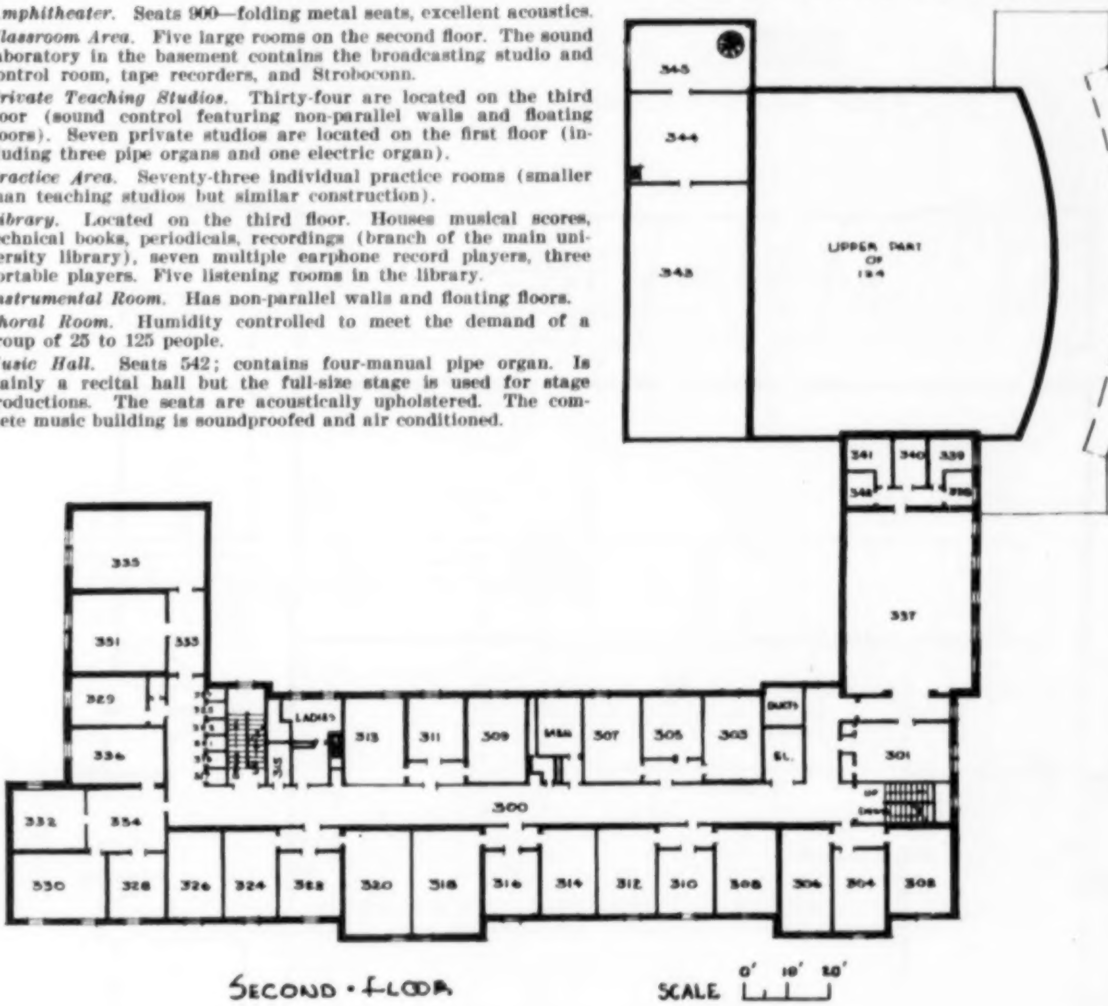


Illustration 83

MUSIC BUILDING

Third Floor, Florida State University, Tallahassee

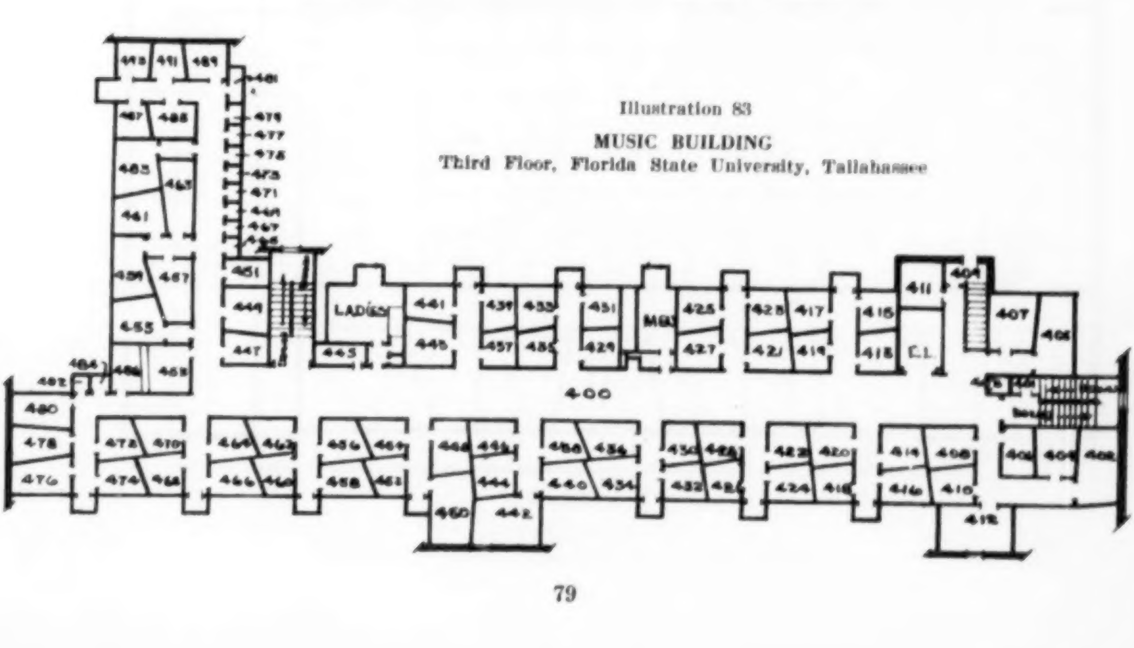


Illustration 85

MUSIC BUILDING
University of Colorado, Boulder

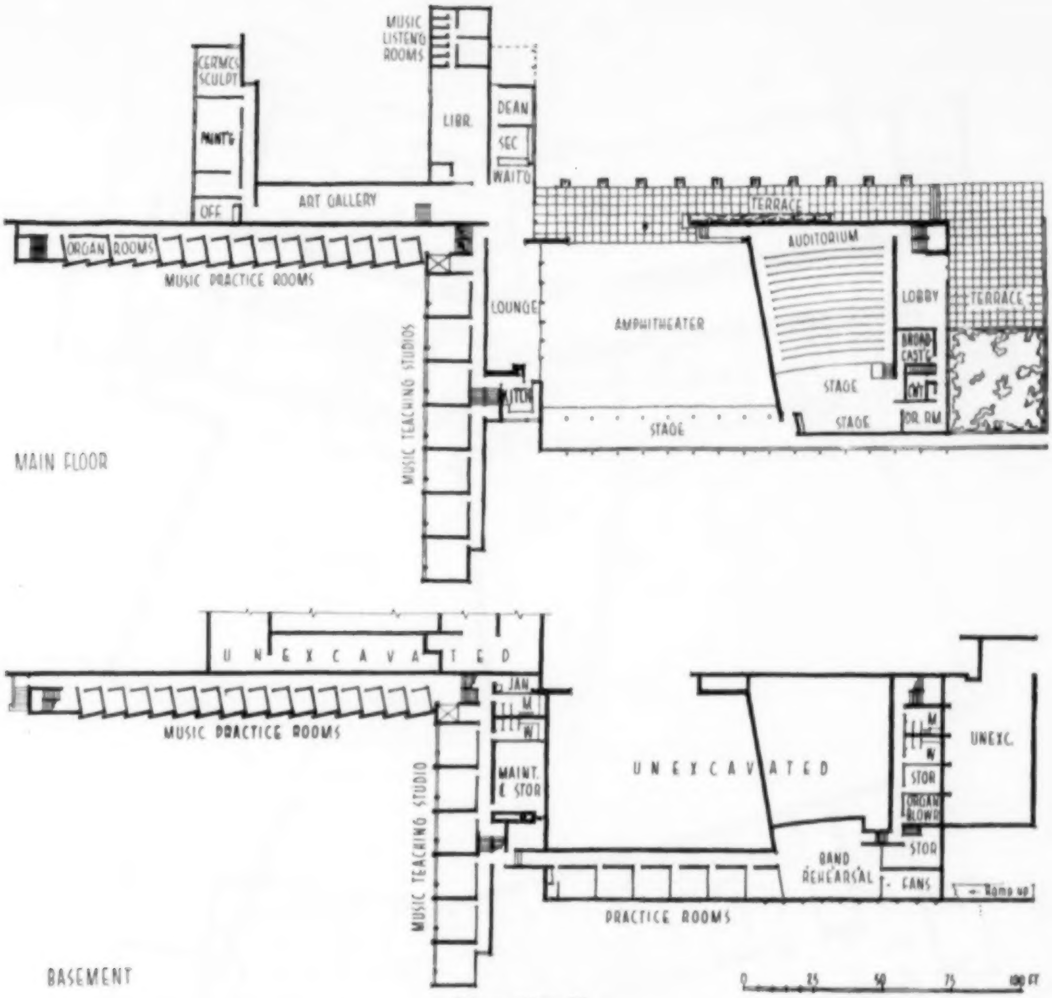


Illustration 86

FIRST FLOOR PLAN OF THE FINE ARTS BUILDING
Maryville College, Maryville, Tennessee. Schweikher & Elting, Architects

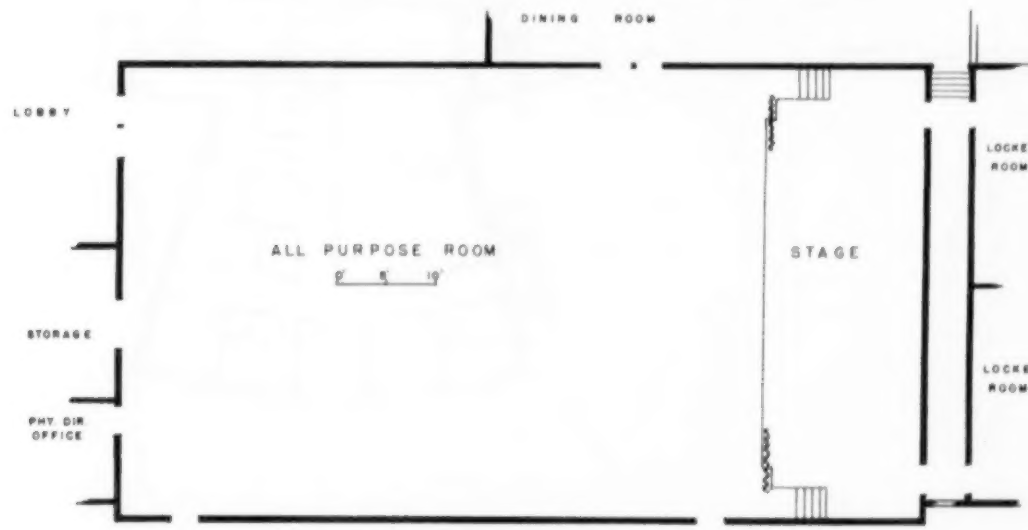


Illustration 87

ALL-PURPOSE ROOM
M. C. J. Billingham, Architect, Kalamazoo, Michigan

Illustration 88

MUSIC BUILDING

Ground and First Floor Plans, Western Michigan College of Education, Kalamazoo

Ground Floor Above; First Floor Below

Illustration 80

MUSIC BUILDING

Second and Third Floor Plans, Western Michigan College of Education, Kalamazoo

Third Floor Above; Second Floor Below

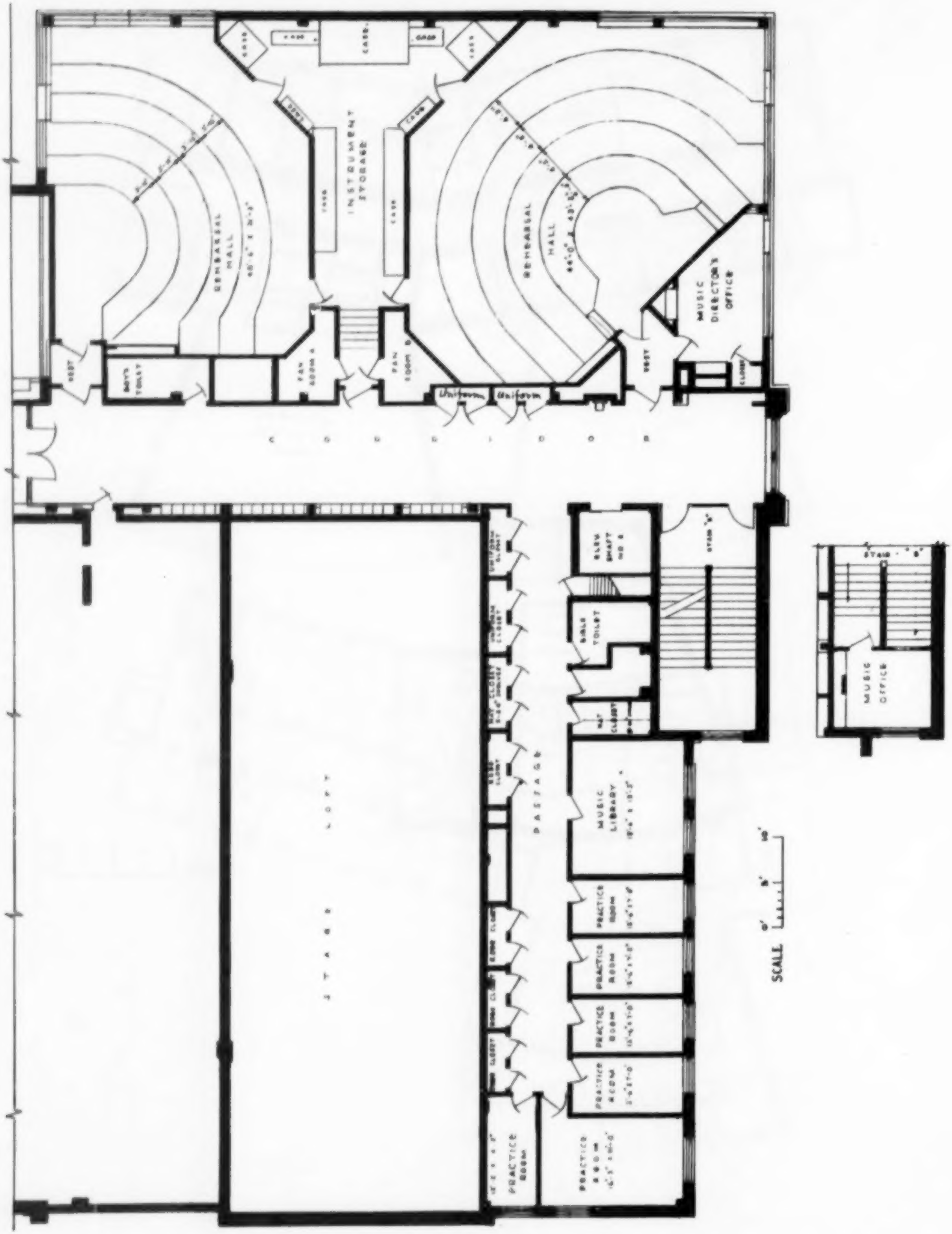


Illustration 90

MUSIC DEPARTMENT LAYOUT

Sexton High School, Lansing, Michigan. Clark R. Ackley, Architect

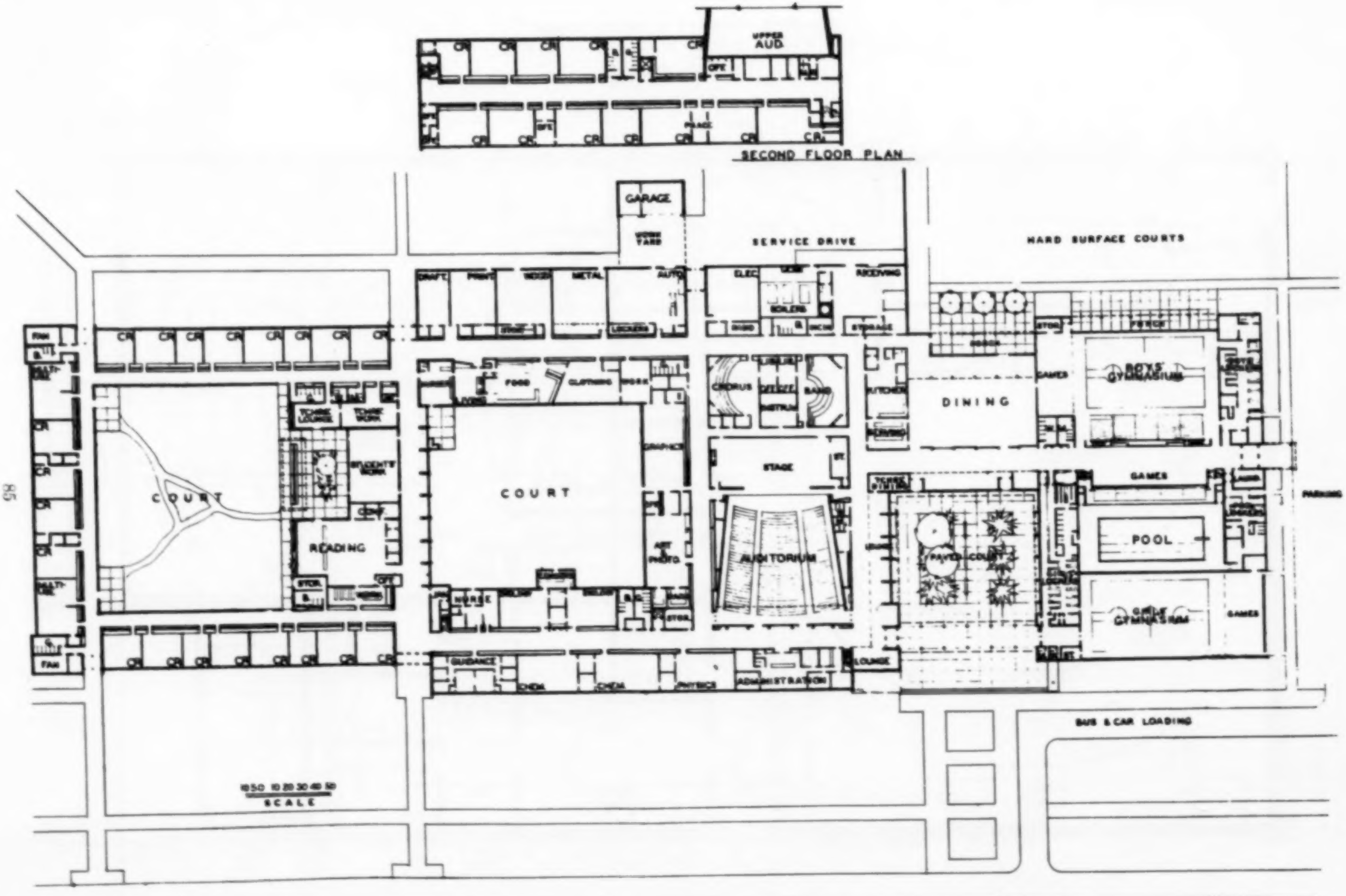


Illustration 91

EDSEL FORD HIGH SCHOOL, DEARBORN, MICHIGAN
Eberle M. Smith Associates, Architects and Engineers

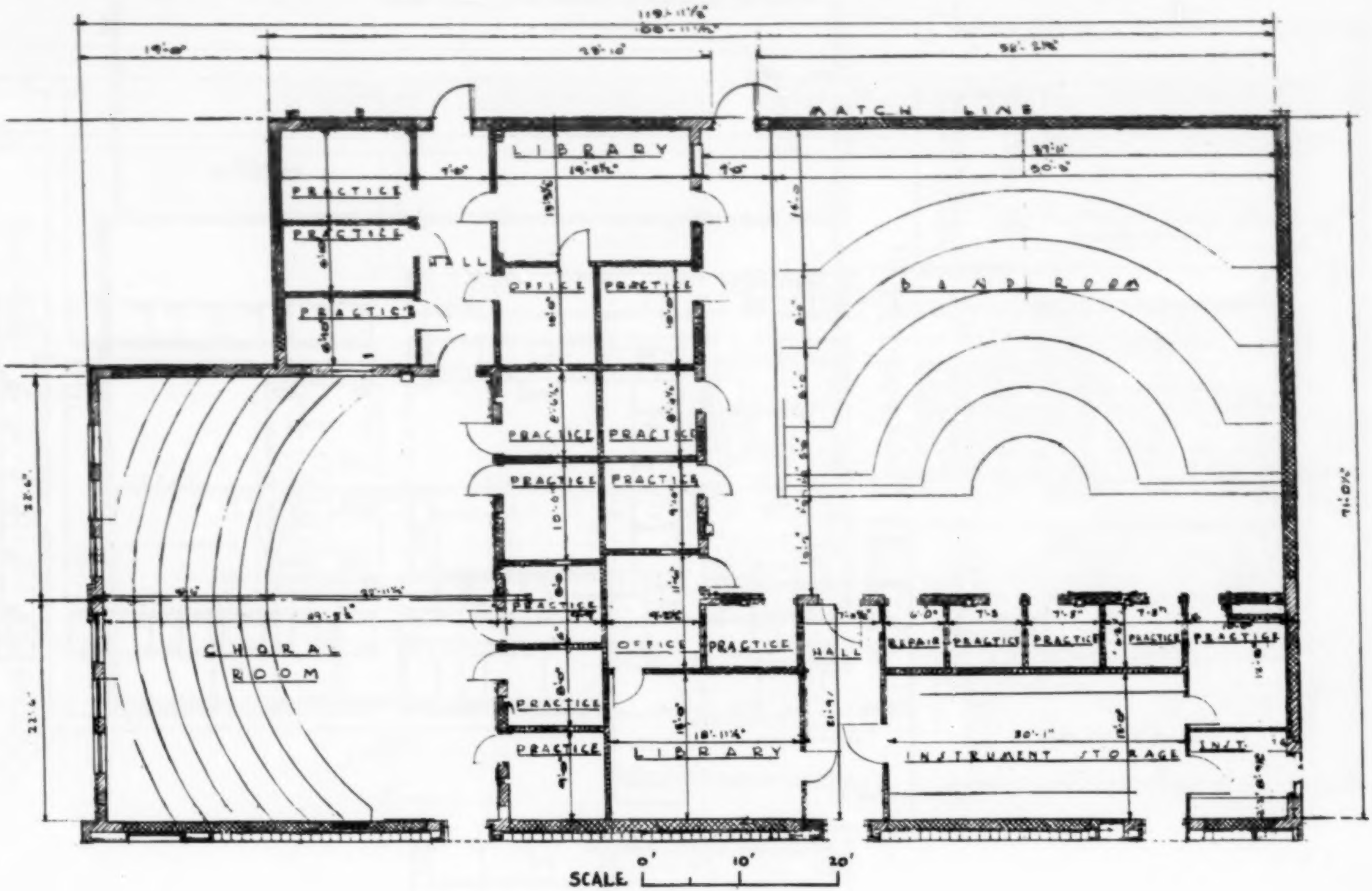


Illustration 92

PARMA SENIOR HIGH SCHOOL, PARMA, OHIO
Fulton Krinsky & Delamotte, Architects

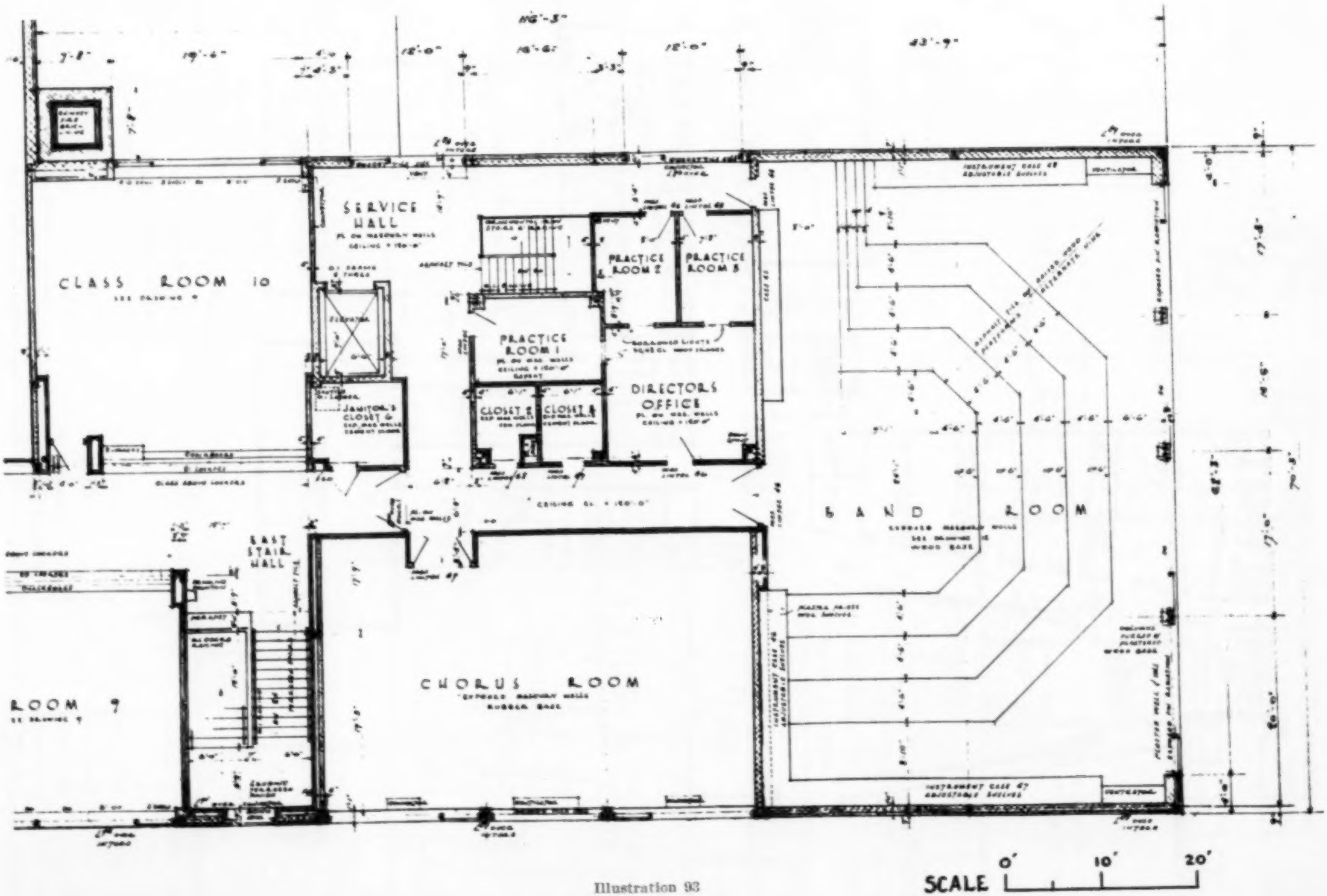


Illustration 93

MUSIC DEPARTMENT
Northeast In.ermediate School, Midland, Michigan

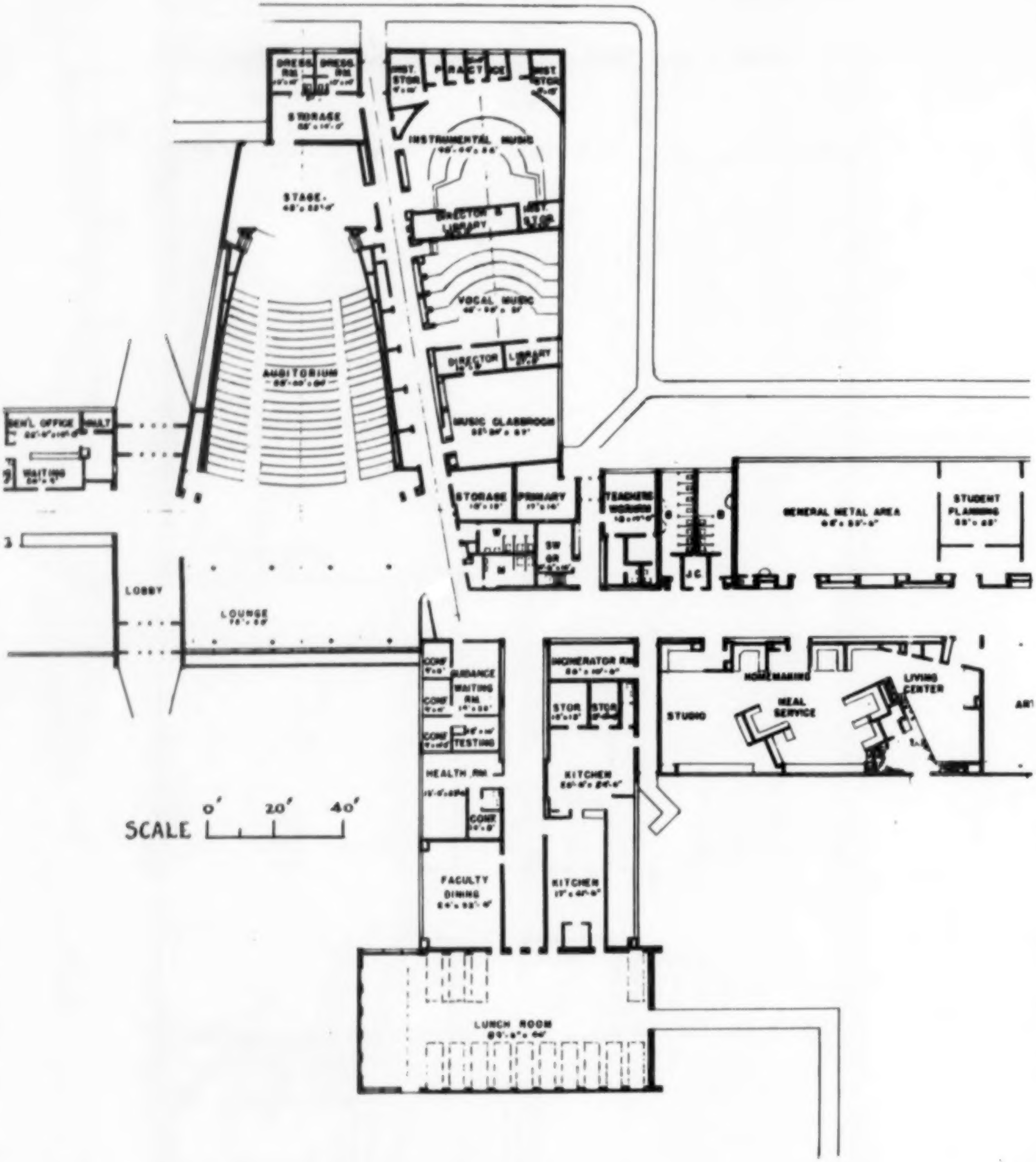
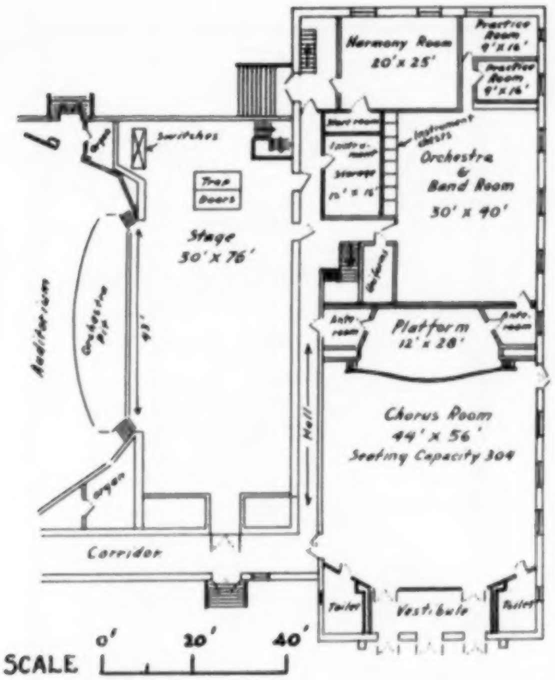


Illustration 94

JUNIOR HIGH SCHOOL

O. L. Smith Junior High School, Dearborn, Michigan. Jahr-Anderson Associates, Inc.



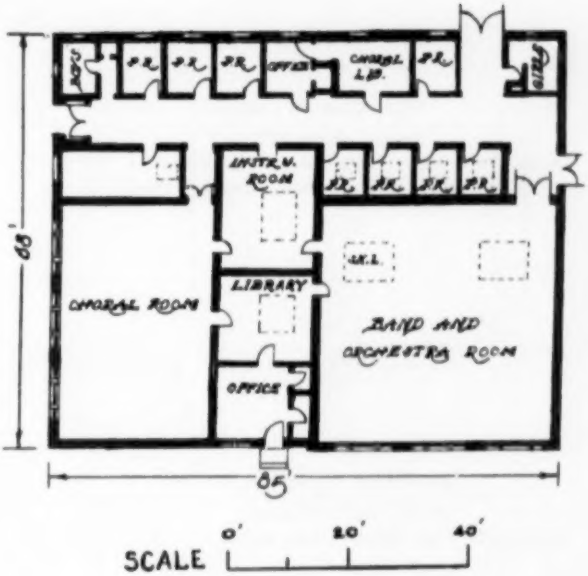


Illustration 96

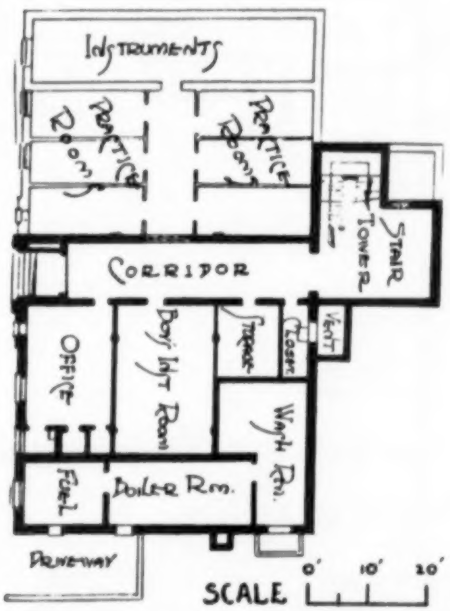
MUSIC BUILDING

Union High School, Los Gatos, California

Illustration 95

PARTIAL FIRST FLOOR PLAN

Walnut Hills High School, Cincinnati, Ohio.



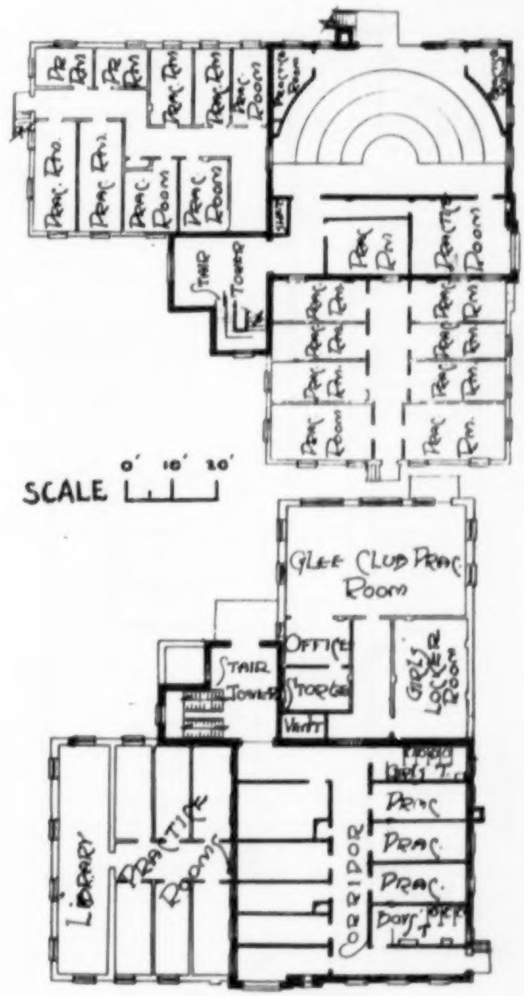


Illustration 97

HIGH SCHOOL BAND BUILDING

First Floor Plan, Lenoir, North Carolina

Illustration 98 (Right)

HIGH SCHOOL BAND BUILDING

Lenoir, North Carolina

Above: Third Floor Plan—Below: Second Floor Plan

Illustration 99 (Right)

MUSIC DEPARTMENT

George Washington High School, San Francisco, Calif.
Partial First Floor and Basement Plan

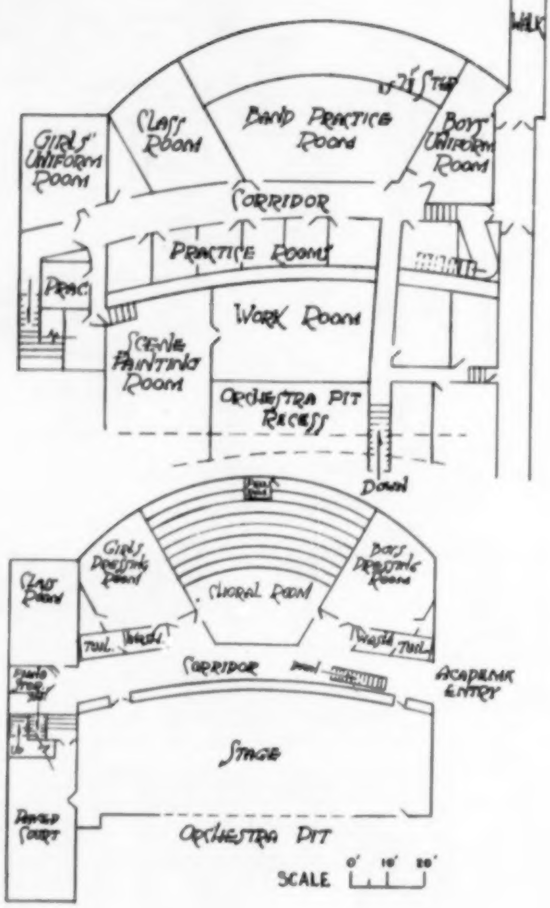
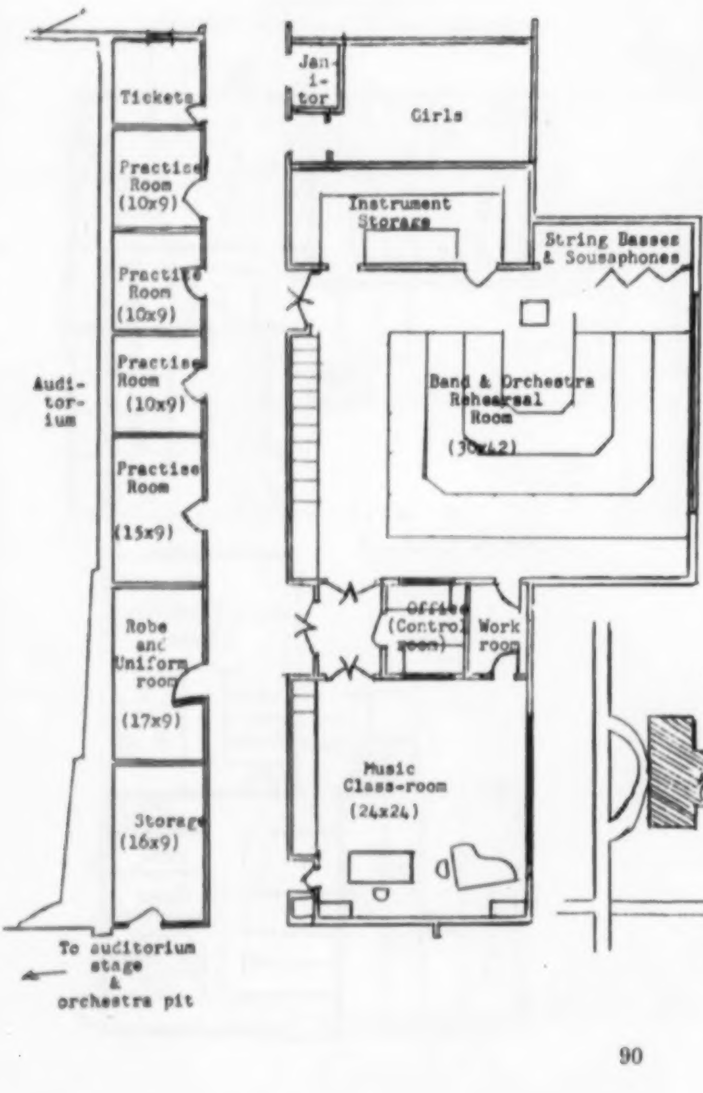


Illustration 100 (Below)

MUSIC DEPARTMENT

Glens Falls High School, Glens Falls, New York



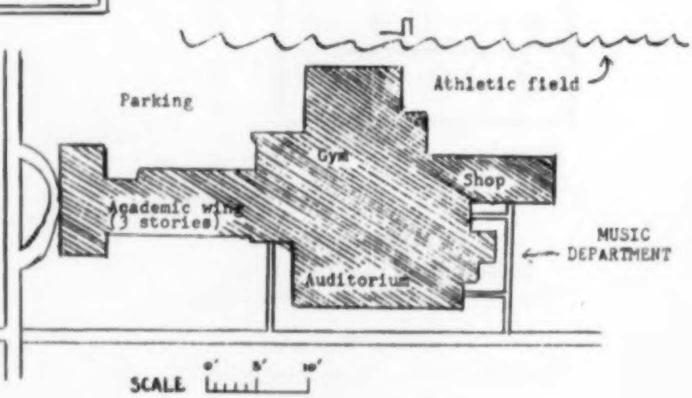


Illustration 101

PLAN FOR A TWO-TEACHER MUSIC DEPARTMENT

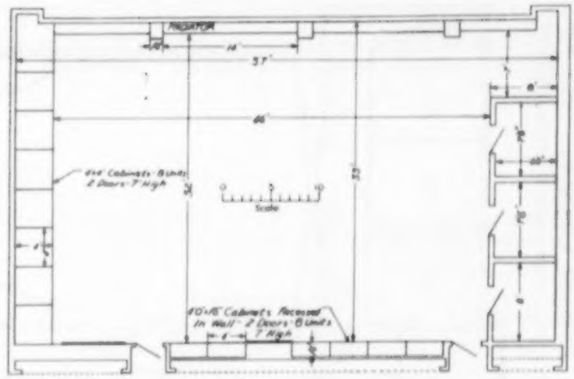


Illustration 102

BAND REHEARSAL ROOM

Community High School, Blue Island, Illinois

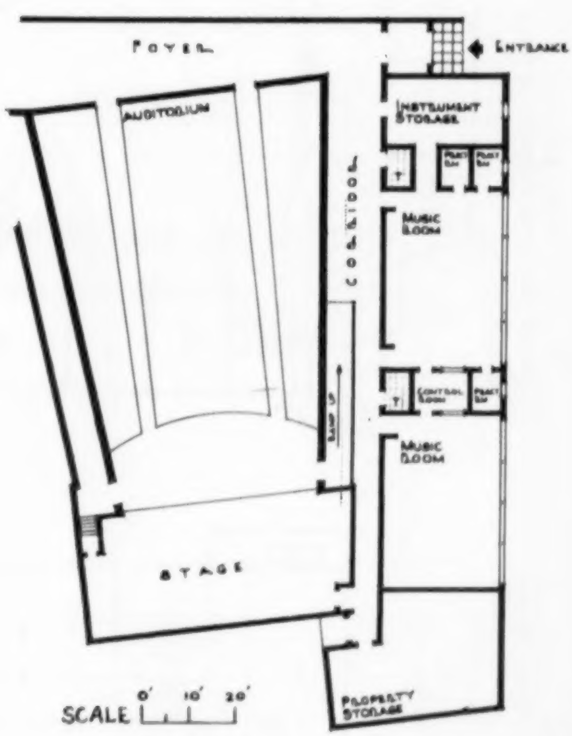


Illustration 103

MUSIC DEPARMENT

Harper Elementary School, Evansville, Indiana

It may be noted that the music rooms are located in an area isolated from the other rooms, yet close to the auditorium and with outside entrance nearby. The vocal and instrumental rooms are each 25' x 35' with an inter-connecting control room for recording equipment. Three individual practice rooms, each 6' x 8' are provided. An instrument storage room, 25' x 14' is next to the instrumental music room and close to an outside entrance.

Illustration 106

MUSIC BUILDING

Third Floor Plan, University of Idaho, Moscow

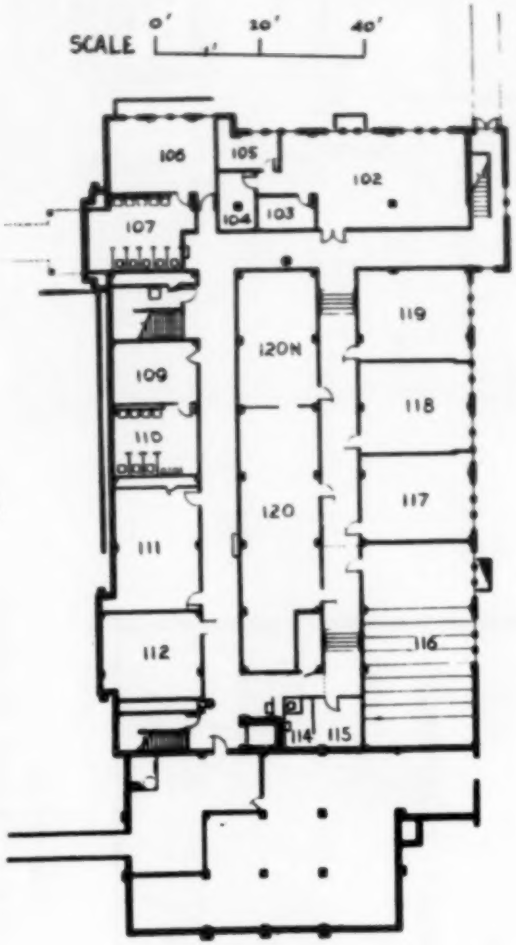


Illustration 105

MUSIC BUILDING

Second Floor Plan, University of Idaho, Moscow

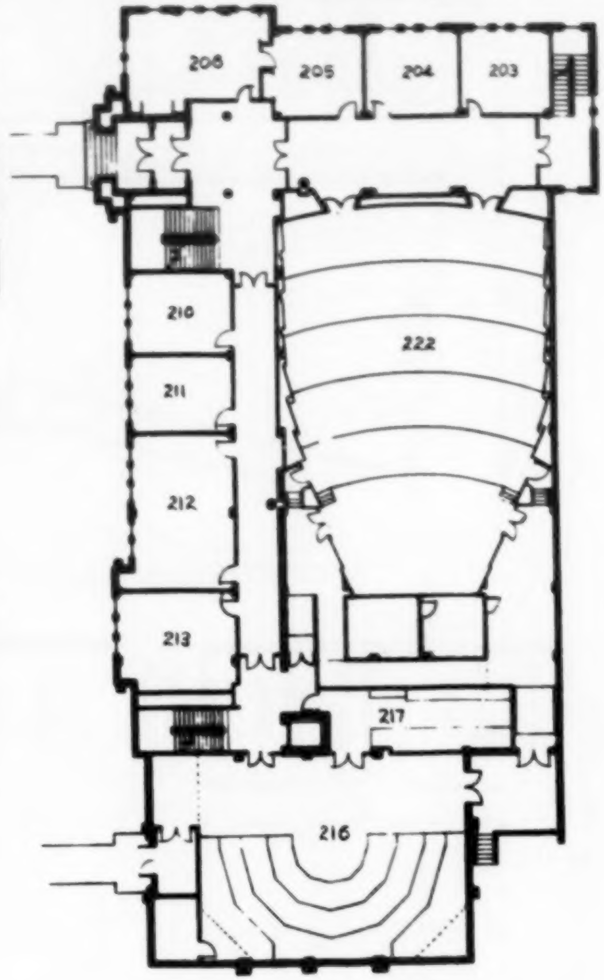
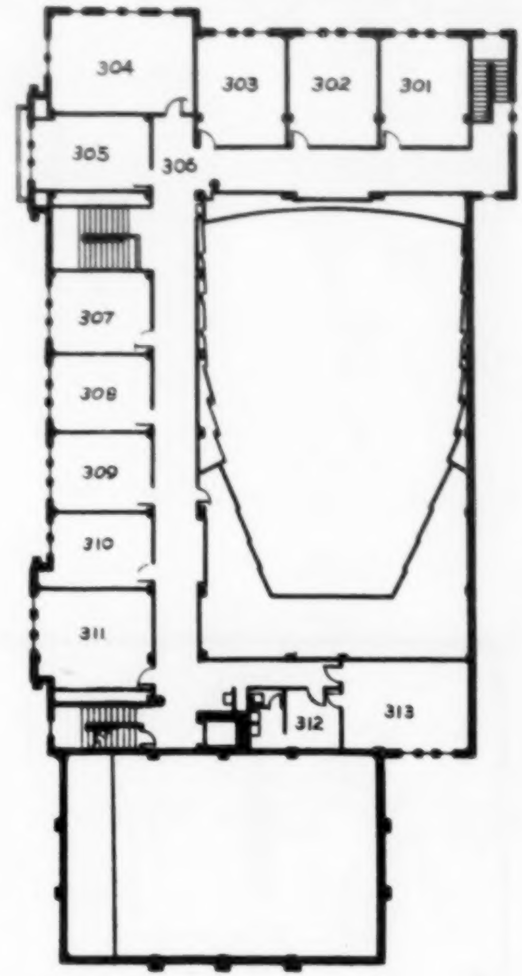


Illustration 104

MUSIC BUILDING

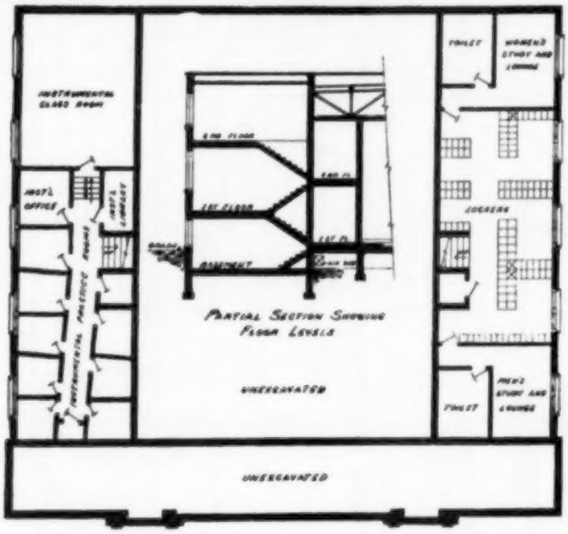
First Floor Plan, University of Idaho, Moscow



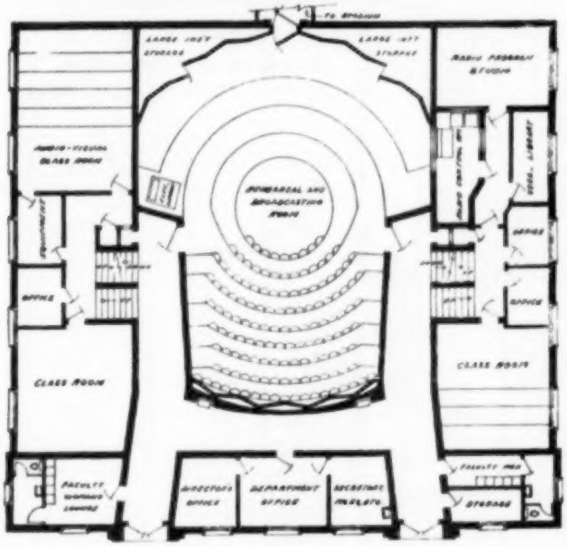
102—Reading Room
103—Listening Room
104—Listening Room
105—Listening Room
106—Women's Lounge
107—Women's Toilets
109—Men's Lounge
110—Men's Toilets
111—Storage
112—Mechanical Room
114—Men's Toilets
115—Men's Lounge
117—Classroom
118—Classroom
119—Classroom
120—Student Activities Room
120N—Music Ed. Workshop
203—Studio
204—Studio
205—Admin. Office
206—Director's Office
210—Studio
211—Studio
212—Organizational Music
213—Green Room
216—Inst. Rehearsal Room
217—Inst. Storage
222—Recital Hall
301—Studio
302—Studio
303—Studio
304—Studio
305—Studio
307—Studio
308—Studio
309—Studio
310—Studio
311—Studio
312—Women's Lounge
313—Organ Practice

Illustration 107

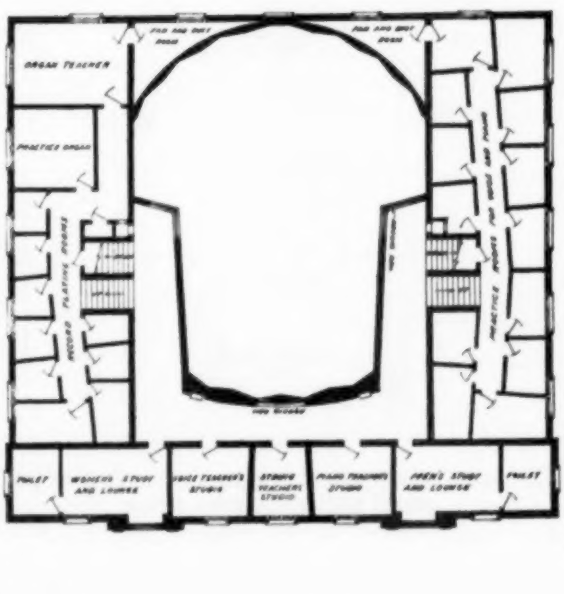
MUSIC BUILDING (CONVERTED MEN'S GYMNASIUM)
East Tennessee State College, Johnson City



BASEMENT PLAN. The side areas are six steps below the first floor corridor and convenient to the large central room and to the building as a whole. The left area is devoted exclusively to instrumental activities. It consists of a large classroom, office, library, and nine rooms for individual or small ensemble practice. The right area contains individual lockers to accommodate instruments, uniforms, etc.



FIRST FLOOR PLAN. The central area contains the administrative offices and the multiple-purpose room. The semi-circular risers at the rear are for instrumental organizations and the risers opposite, upon which seats are indicated, are for choral organizations. This room is for large group rehearsals, direct broadcasting, recording of programs for delayed broadcasts, and serves as a little auditorium for recitals, clinics, and lectures. The side areas consist of classrooms, offices, choral library, and radio facilities. The radio control room is adequate to contain a console, two turntables, tape and wire recording units.



SECOND FLOOR PLAN. The front area contains the studios for private study. Here also are the study and lounge rooms. View windows from the corridor afford an opportunity to observe activities being conducted in the large central room. The left side area has nine record playing rooms. These are used in conjunction with courses in Music Appreciation, Literature, Score Reading, Conducting, and Form and Analysis. Teaching and practice facilities for organ are in this area. The right side area consists of thirteen practice rooms for students.

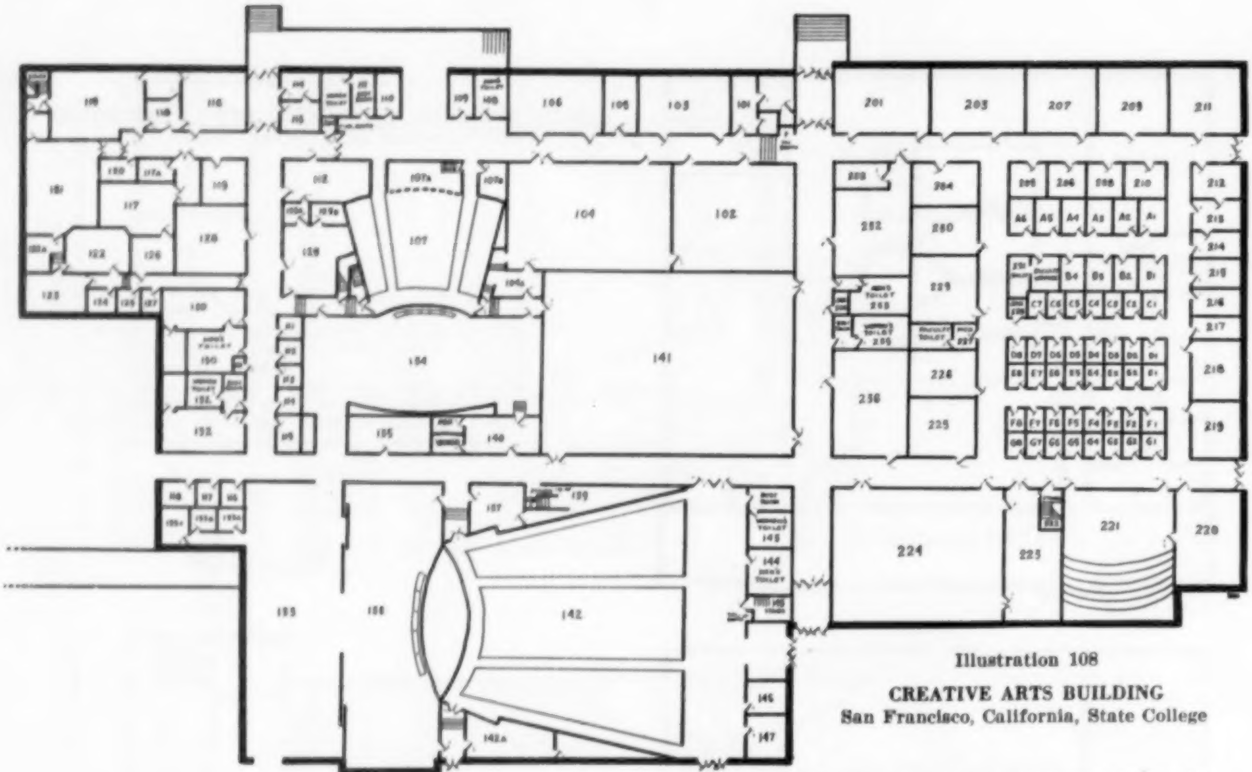


Illustration 108

CREATIVE ARTS BUILDING
San Francisco, California, State College

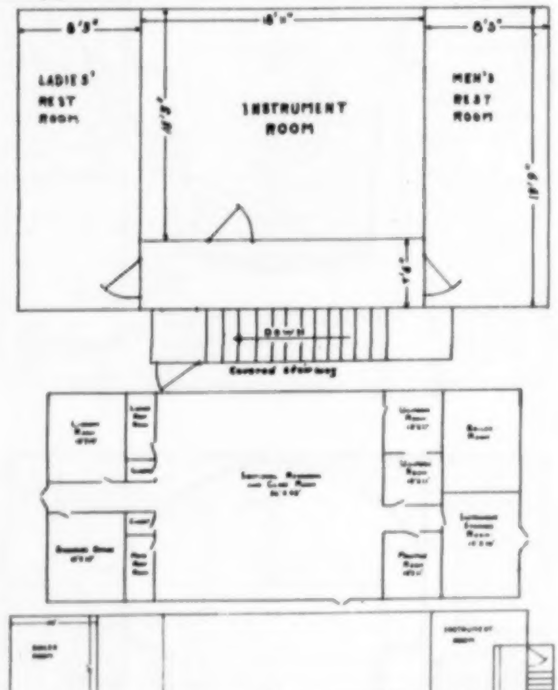


Illustration 110

INSTRUMENT ROOM, SECTIONAL REHEARSAL, CLASS-ROOM AND REHEARSAL ROOM
University of Utah, Salt Lake City

Illustration 109

SPECIFICATIONS

School of Music Building, University of Wichita, Kansas
Designed for 300 Music major capacity

(Construction of Music Unit of University of Wichita Fine Arts Center was started in 1954, see picture from architect's drawing, on title page.)

No. of Rooms		Size	Total Sq. Ft.
6	Organ and small ensemble practice rooms	8'x14'	672
48	Practice room cubicles	7'x 8'	2,688
23	Instructor's studios	13'x16'	4,784
7	Department head studios	13'x24'	2,184
1	Band and orchestral rehearsal room and storage—16' ceiling	44'x72'	3,168
1	Choir and opera workshop rehearsal room and storage—16' ceiling	36'x72'	2,592
1	Music office	24'x13'	312
1	Music director's office	20'x13'	260
1	Library room—records, scores, etc.	26'x13'	338
1	Record listening room	24'x13'	312
2	Dark rooms for filmstrips	7'x 8'	112
1	Scenery storage room and theater rehearsal room	40'x30'	1,200
1	Recital hall—seating capacity 500	50'x80'	4,000
1	Stage (reversible) with fly loft, 50' ceiling	50'x30'	1,500
1	Classroom—capacity 100	24'x35'	840
3	Classrooms—capacity 50	24'x30'	2,160
3	Classrooms—capacity 30	24'x26'	1,872
2	Ensemble practice rooms	13'x26'	676
1	Music education department office	13'x20'	260
	Utility rooms, halls, toilets, furnace room, etc.—nonusable space		12,400
2	Shower rooms, 6 shower heads each	8'x18'	288
1	Locker room	8'x18'	144
1	Combination dressing room—ballet rehearsal room (under stage)	30'x50'	1,500
2	Dressing rooms—adjacent to stage	13'x16'	416
	Reception room	25'x40'	1,000
	Outdoor theater—seating capacity 3,500. (Building layout to enclose outdoor theater utilizing reversible stage of Recital Hall)		
	Grand total square feet		45,678
	Cost at $12.00 per Sq. Ft. (estimated)		$548,136.00
	Capital expenditure		
	Music equipment—pianos, organs, music instruments		152,500.00
	TOTAL		$700,636.00

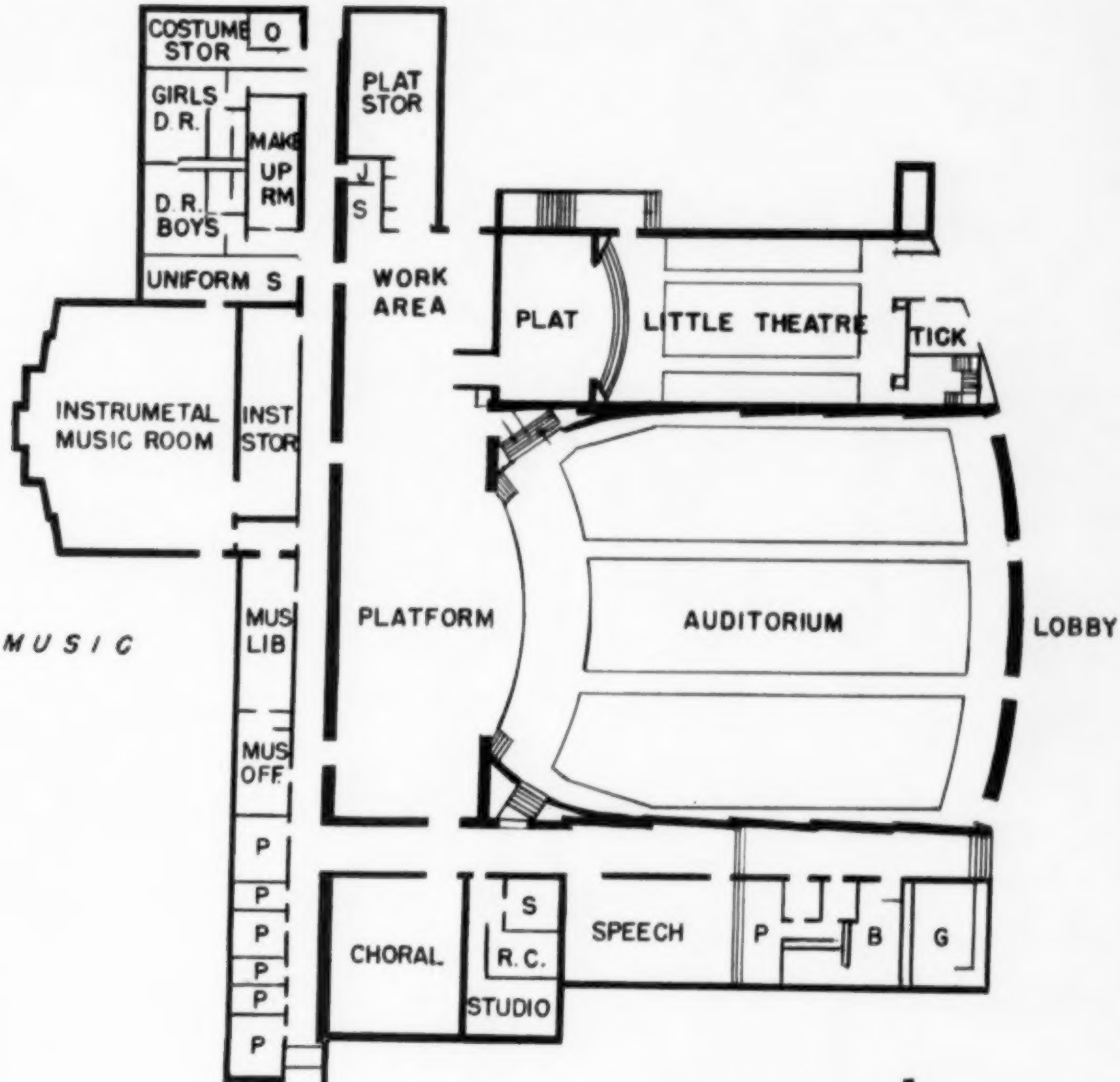


Illustration 111 (Above)

FIRST FLOOR KEY PLAN
Ann Arbor High School, Ann Arbor, Michigan

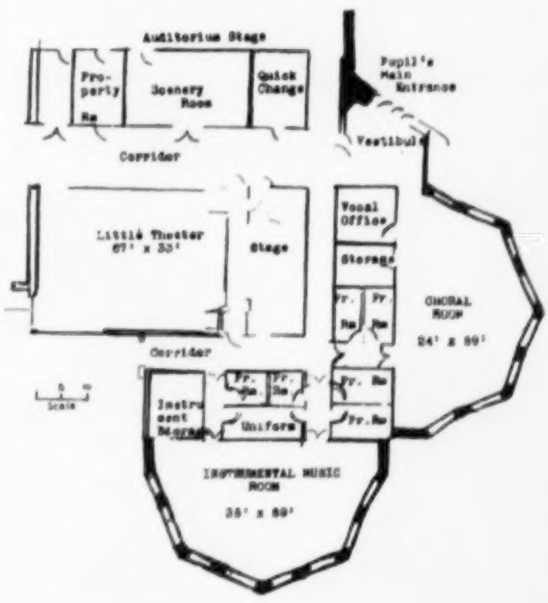


Illustration 112 (Right)

PROPOSED PLAN OF HIGH SCHOOL MUSIC ROOMS
Mt. Vernon, New York

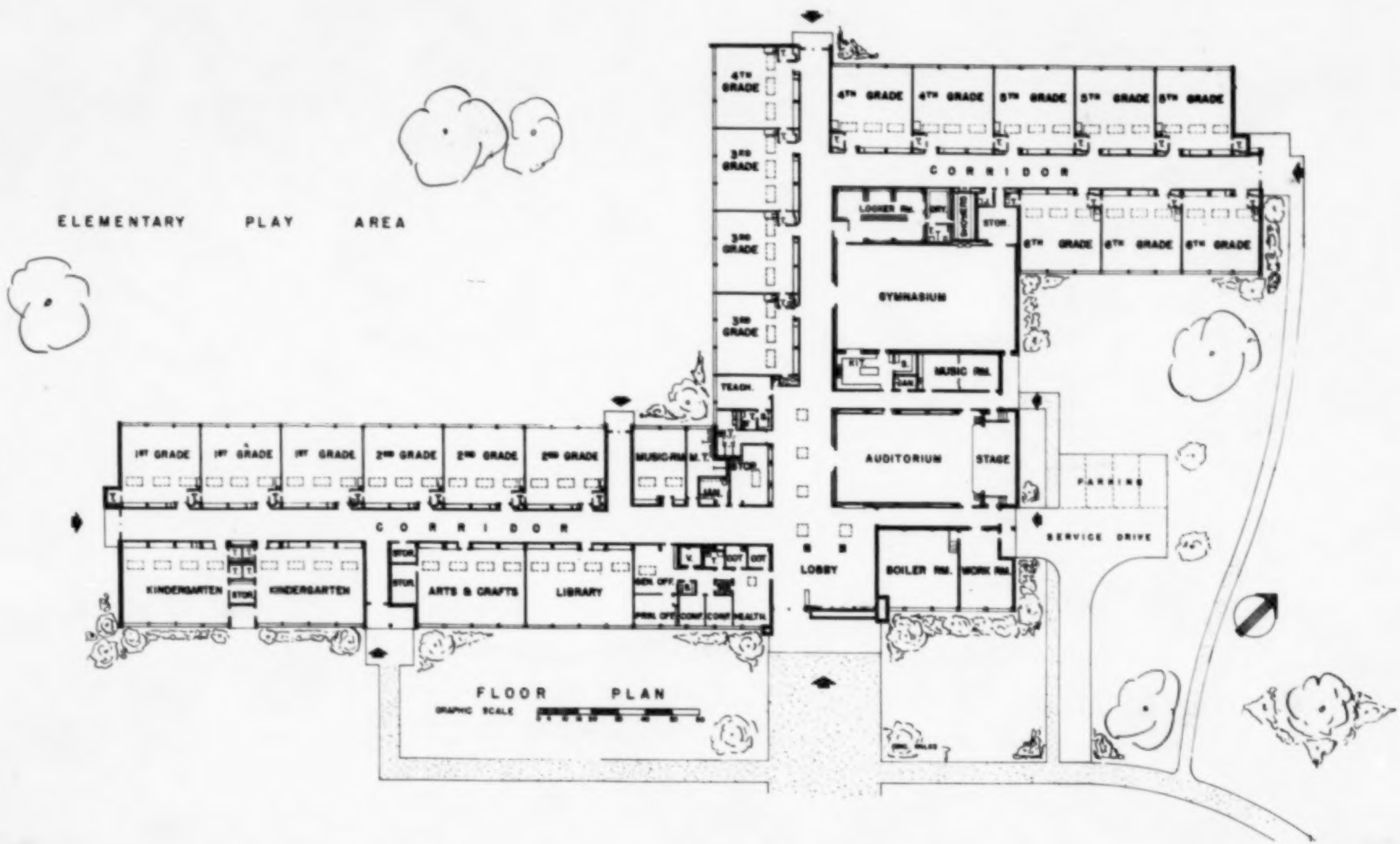


Illustration 113

ELEMENTARY SCHOOL

Northwest Elementary School, Ann Arbor, Michigan. Louis G. Kingscott, Architects and Engineers, Kalamazoo, Michigan